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PREFACE

THIS Bulletin, in continuation of Bulletin No. 59, contains a second collection of one hundred short notes on Indian Insects, their names, habits, lifehistories and occurrence either in previously unrecorded localities or on new foodplants. As previously explained, such notes are commonly made by workers in all branches of entomology but are only too often buried away in note-books, reports or files, or, if published, are so scattered that in any case they become inaccessible to the ordinary student. To obviate this, such notes, collected to form Bulletins, will be published as material accumulates.

In the present Bulletin, Note 101 is reprinted from the *Quarterly Journal of the Indian Tea Association*, Notes 120, 146, 159, 174 and 191 from the Madras Agricultural Department's *Year-book* for 1917 (which was issued "for official use only" and remains unpublished in the technical sense), Notes 154 and 155 from the *Entomological News*, Note 156 from the *Journal of the Asiatic Society of Bengal*, and Note 186 from the *Entomologists' Monthly Magazine*.

Besides the above-mentioned Notes which are here reprinted, Mr. T. V. Ramakrishna Ayyar has contributed Notes 119, 166, 171, 177, 188, 192, 194, 195 and 198; Mr. Y. Ramachandra Rao, Notes 114, 129, 151, 169, 181, and 196; Mr. G. R. Dutt, Notes 105 and 106; and P. Susainathan, Note 175. The remaining Notes have been written by myself, the sources of information being indicated in most cases, those described from Pusa Insectary cage-slips having been reared by Mr. C. C. Ghosh, the Insectary Assistant.

T. BAINBRIGGE FLETCHER,
Imperial Entomologist.

PUSA:
1st December 1918.

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Agricultural Research Institute, Pusa

Are Camels Susceptible to Blackquarter, Haemorrhagic Septicaemia and Rinderpest?

BY

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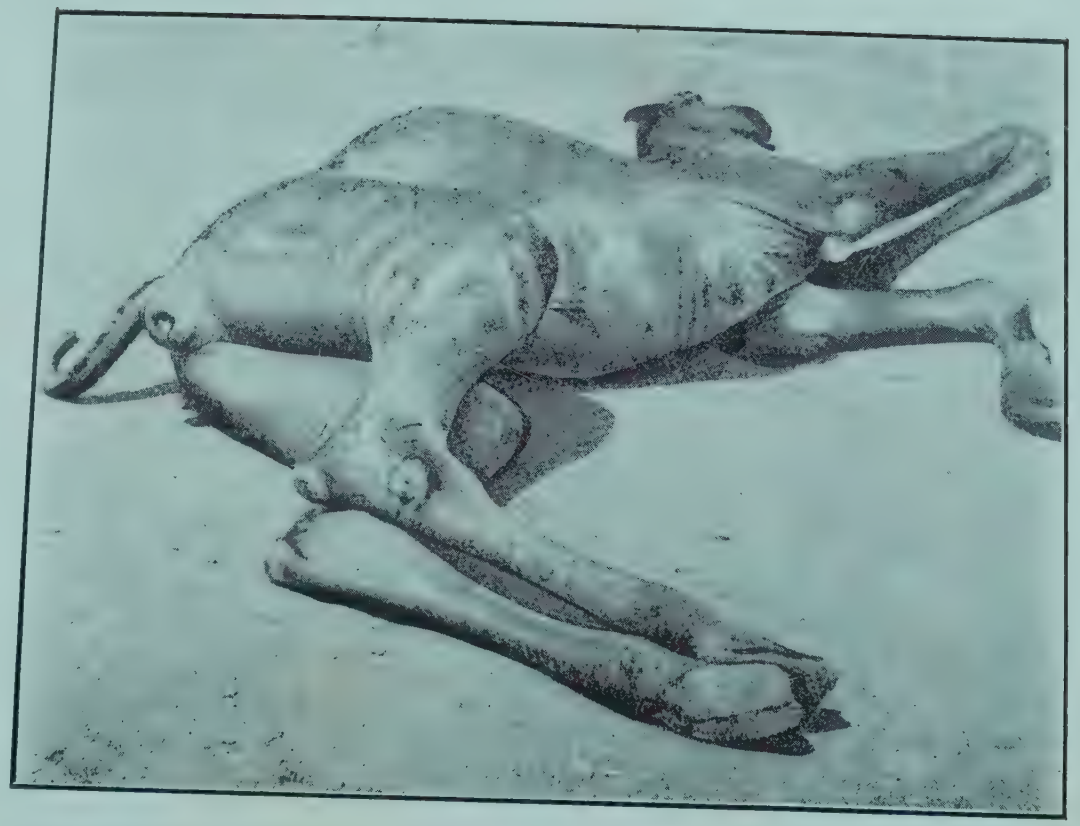


SWELLING OF HIND QUARTERS IN BLACKQUARTER.

Are Camels Susceptible to Blackquarter, Haemorrhagic Septicaemia and Rinderpest?

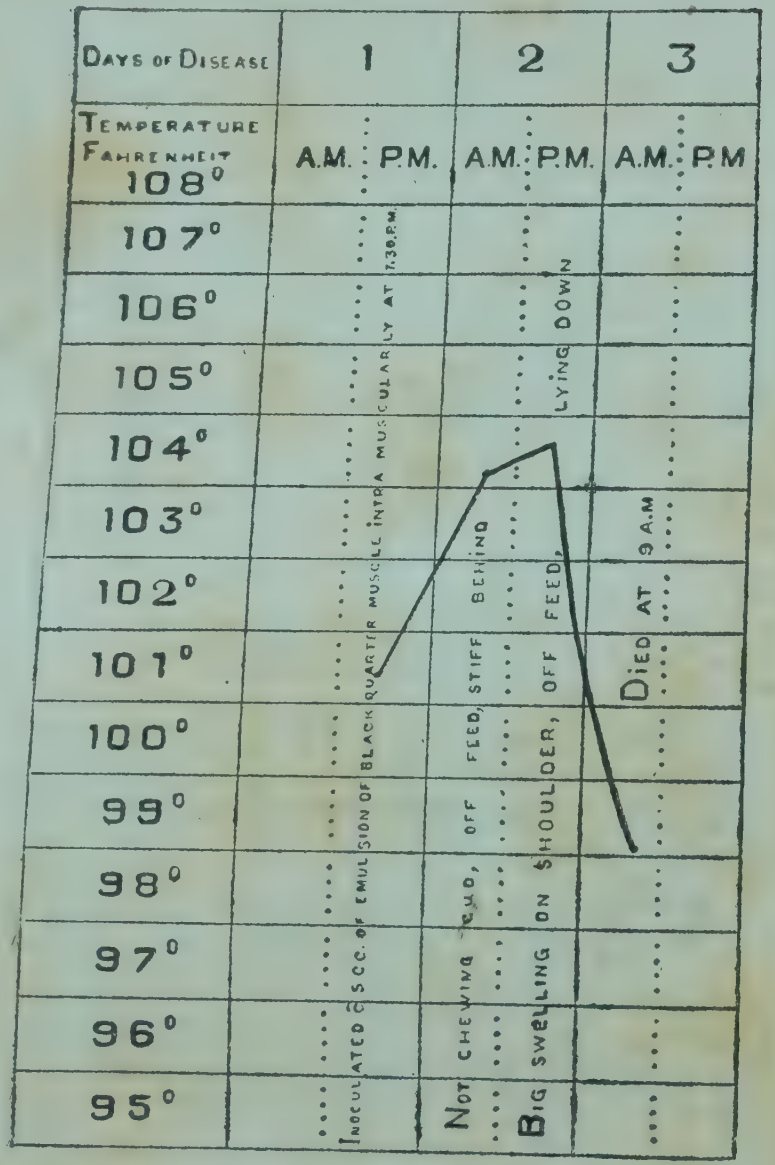
[*Received for publication on the 23rd January, 1918.*]

BLACKQUARTER.

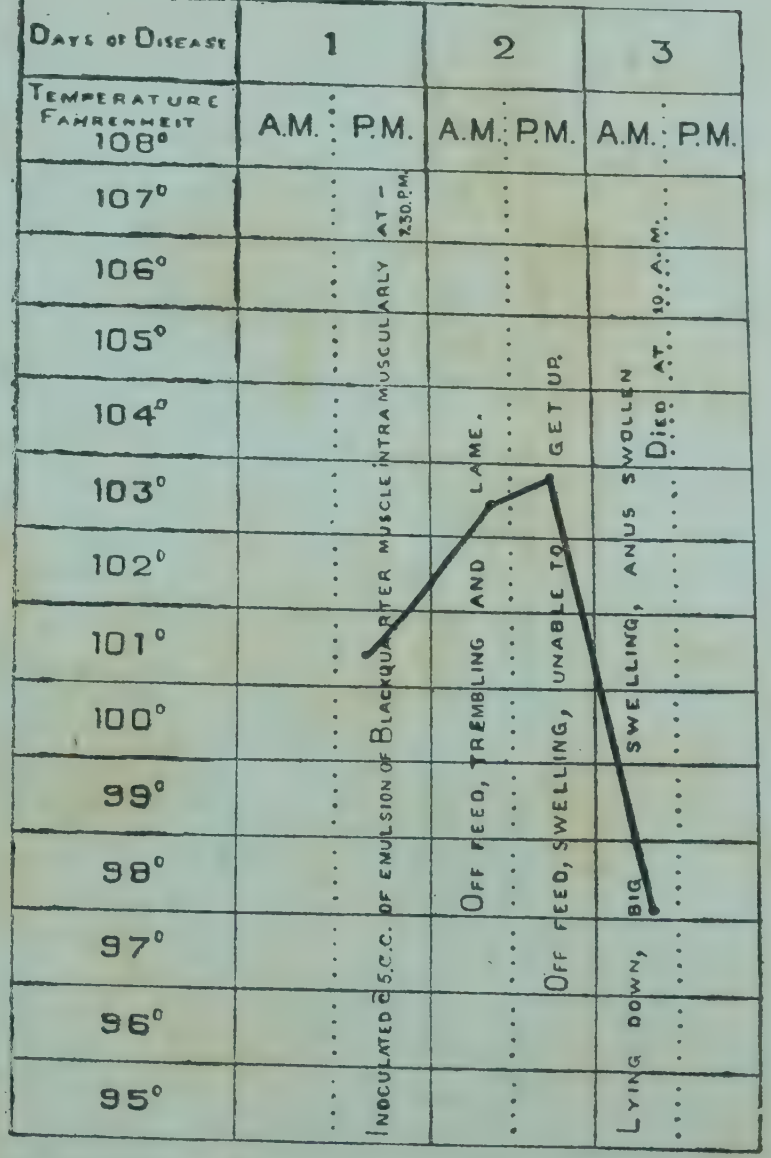
THOUGH such outbreaks of blackquarter as occur among cattle have not been reported amongst camels, deaths from this disease are occasionally stated to occur, but no reliable information regarding the disease in camels is available. To determine the susceptibility of camels to blackquarter, three camels (two—1 year old, and one—7 years old) were inoculated with blackquarter virus; one young buffalo and one calf acting as controls.

The accompanying charts show the course that the disease runs in the camel. The first symptom is a rise of temperature followed by suspension of rumination and loss of appetite. The camel is then noticed to show a disinclination to stand and when walked is noticed to go lâme. After the first appearance of stiffness a swelling soon appears on the shoulder or the hindquarters (according to whether the injection of the virus has been made in the muscles of the shoulder or hindquarters); the swelling is at first slight but rapidly increases in size and becomes emphysematous. Breathing becomes difficult accompanied by grunts. After the swelling has become large the camel lies on his side, and is unable to get up; the breathing becomes more difficult and may be rapid or slow, the face has an agonized look and the temperature falls rapidly before death takes place. On post-mortem the only lesion is the large emphysematous swelling; when cut into, the muscles of the affected part are dark brown to blackish in colour and of a slightly rancid odour and emphysematous.

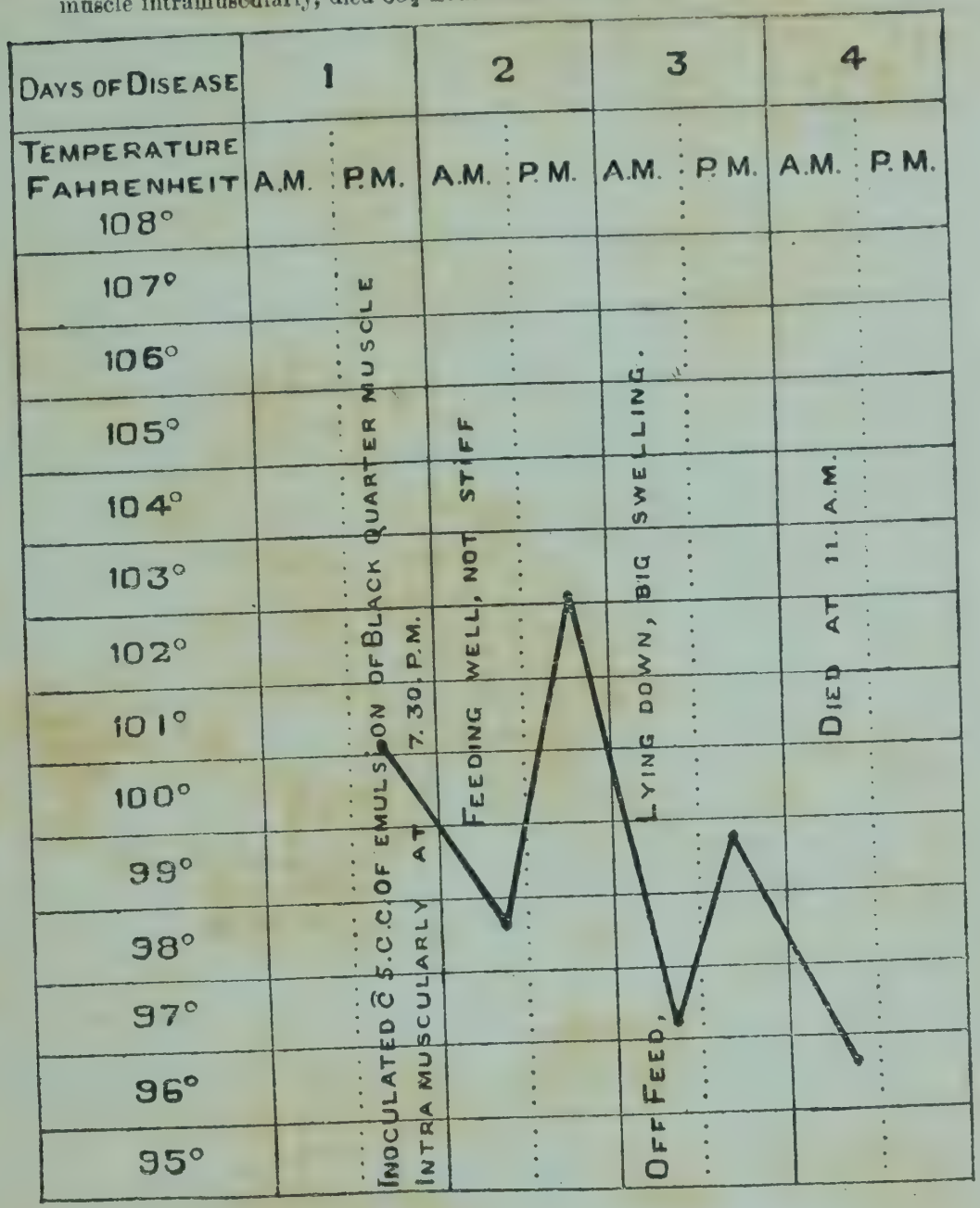
Camel No. 1. Male, 1 year old, inoculated with 5 c.c. of emulsion of blackquarter muscle intramuscularly, died 37½ hours after inoculation.



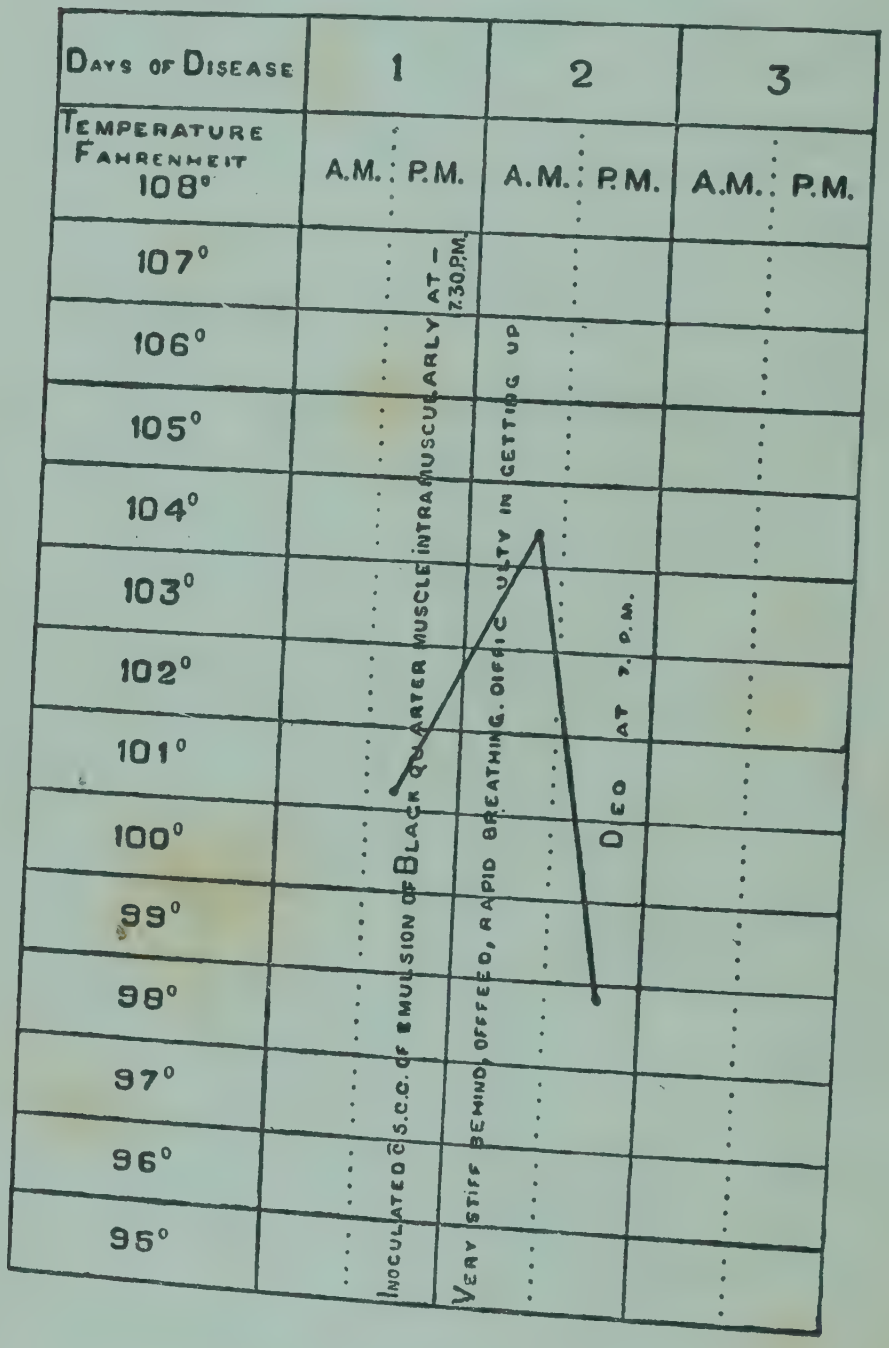
Camel No. 2. Female, 1 year old, inoculated with 5 c.c. of emulsion of blackquarter muscle intramuscularly, died 38½ hours after inoculation.



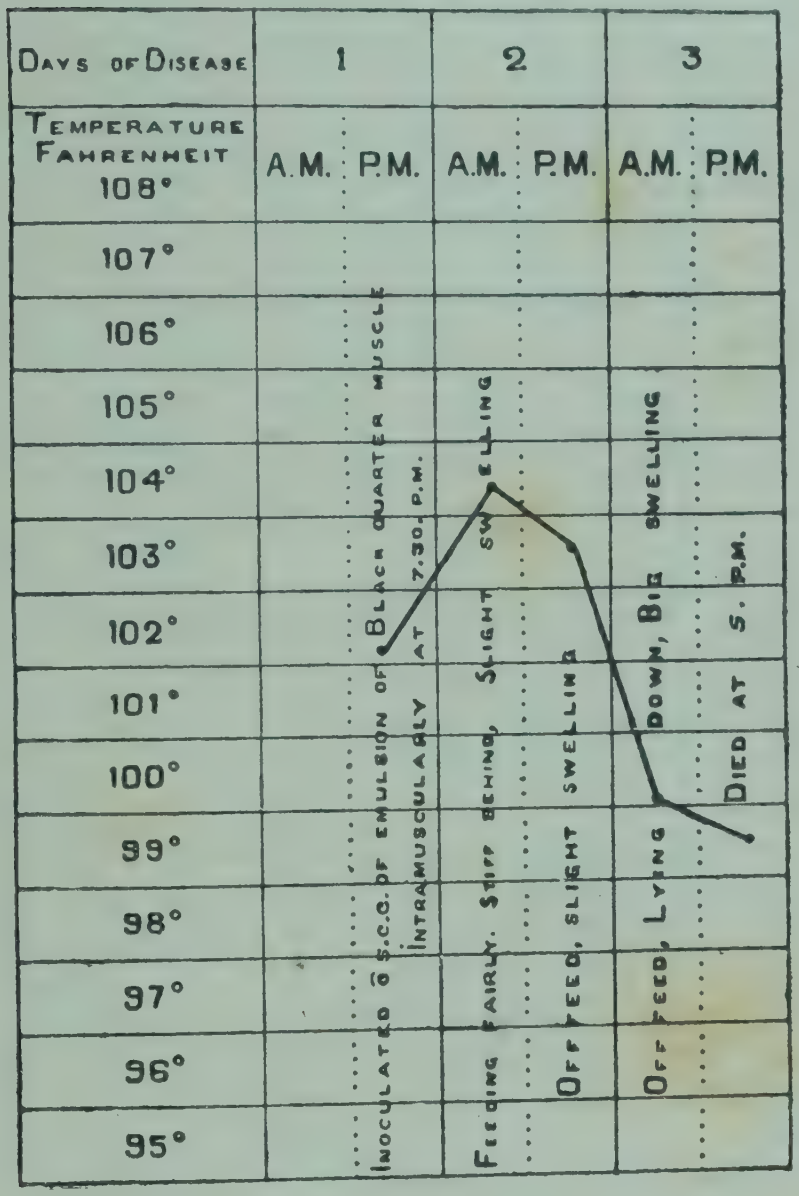
Camel No. 3. Male, 7 years old, inoculated with 5 c.c. of emulsion of blackquarter muscle intramuscularly, died 63½ hours after inoculation.



Control No. 1. Buffalo, 3 months old, male, inoculated with 5 c.c. of emulsion of blackquarter muscle intramuscularly, died 23½ hours after inoculation.



Control No. 2. Calf, male, 9 months old, inoculated with 5 c. c. of emulsion of blackquarter muscle intramuscularly, died 45½ hours after inoculation.



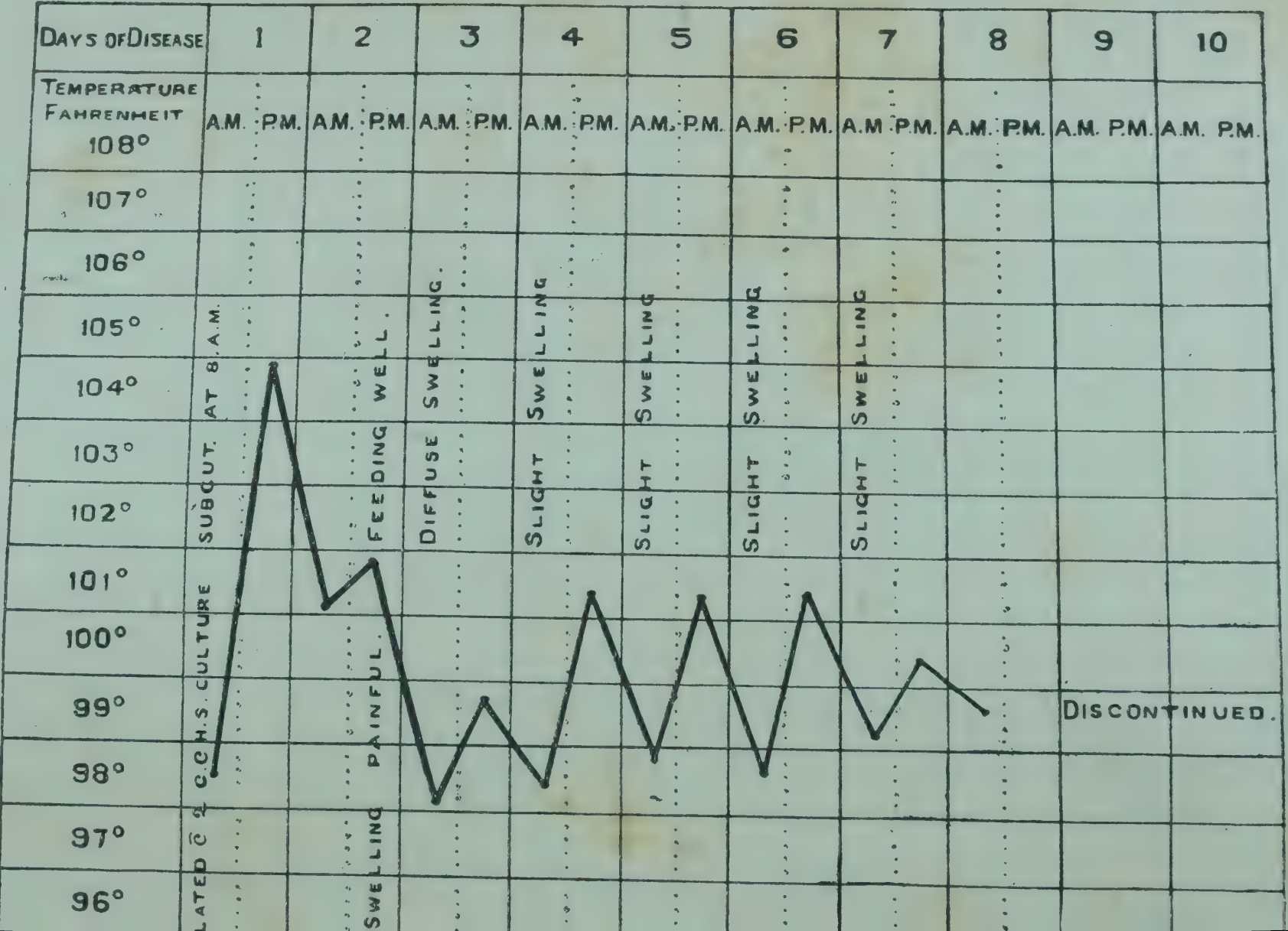
Conclusion. **Camels are as susceptible to blackquarter as cattle.**

HÆMORRHAGIC SEPTICÆMIA.

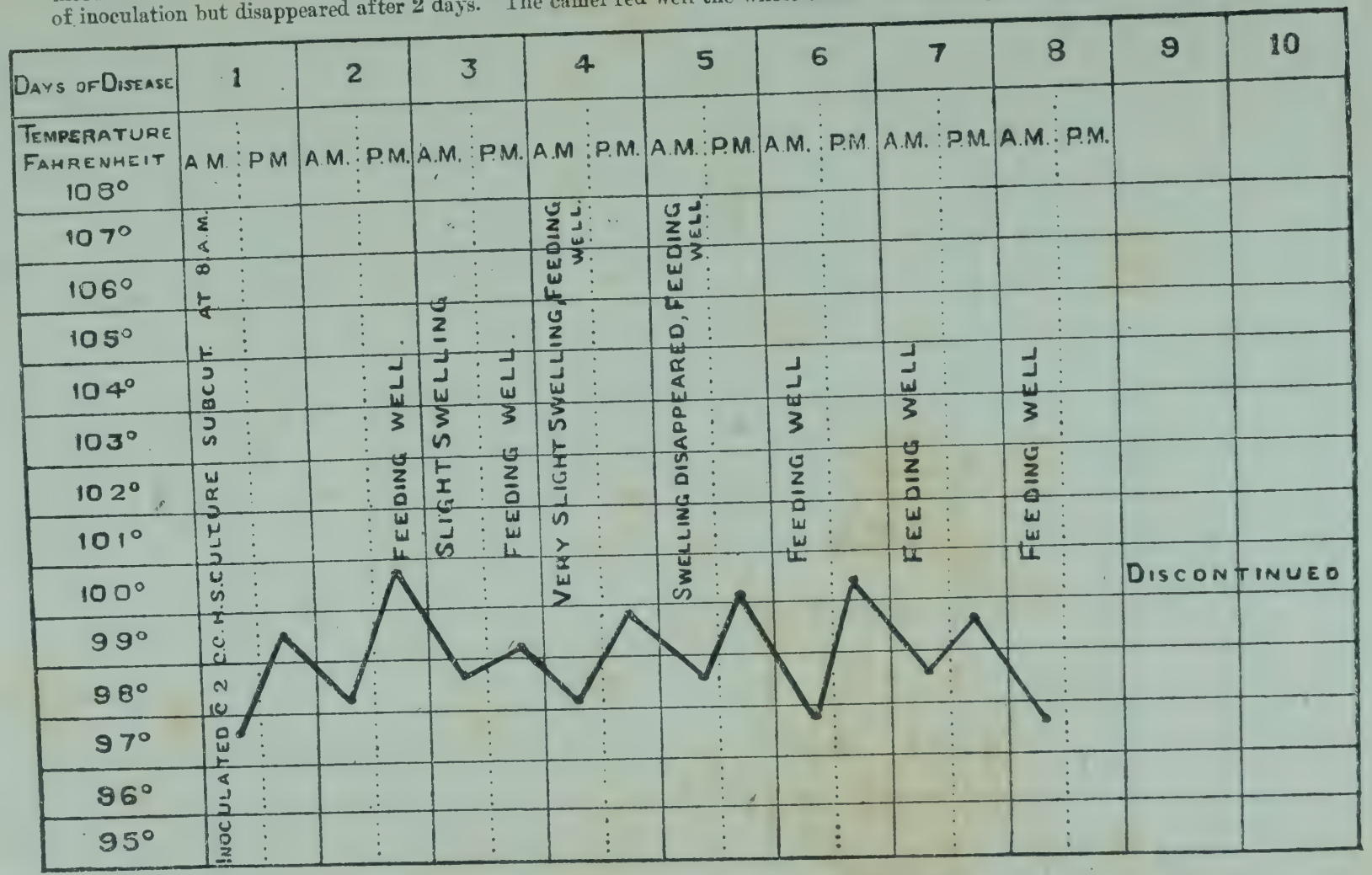
In India the losses amongst cattle from hæmorrhagic septicæmia are very great, but it is not known whether deaths from this disease occur amongst camels.

To determine whether camels are susceptible to this disease 2 camels were inoculated with hæmorrhagic septicæmia culture and 2 calves and 2 rabbits acted as controls.

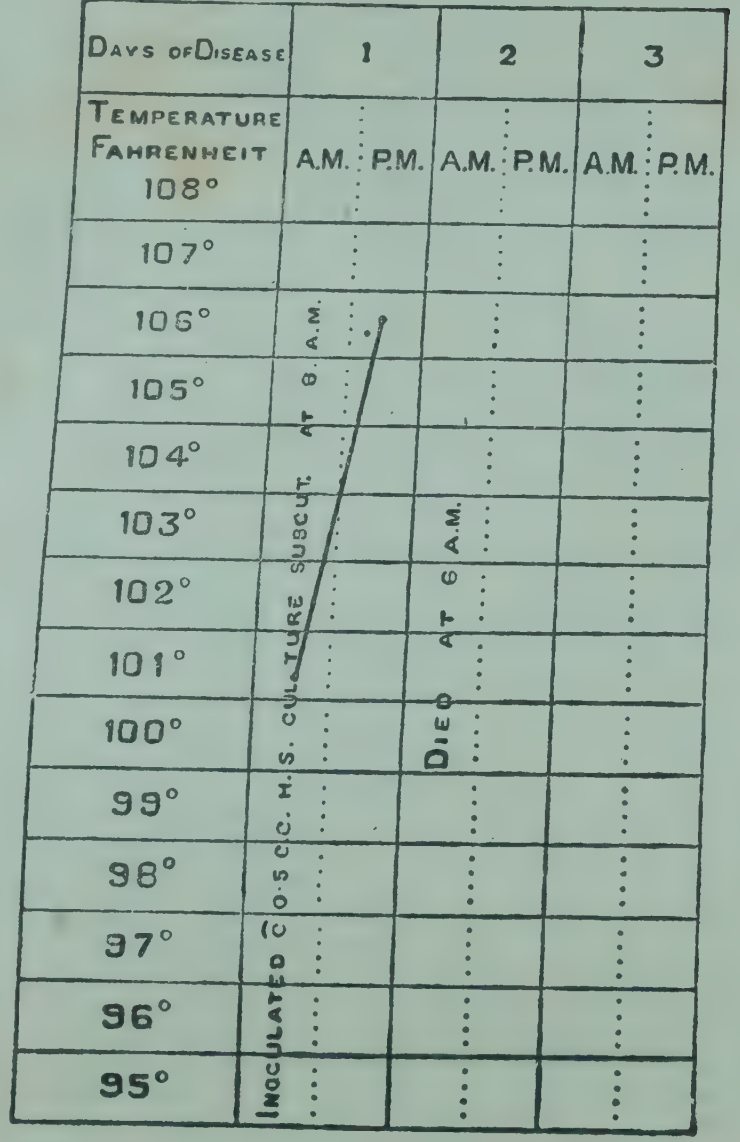
Camel No. 1. Male, 1 year old, inoculated with 2 c.c. hæmorrhagic septicæmia culture subcutaneously. Ten hours after inoculation the temperature rose to 104·8°. Thirty-four hours after inoculation there was a slight swelling, hot and painful, this gradually subsided; the fæces continued normal and the camel continued to feed well. Seventy-four hours after inoculation the temperature became normal and continued so till the 7th day, after which no further observations were made, the camel being in a normal state of health.



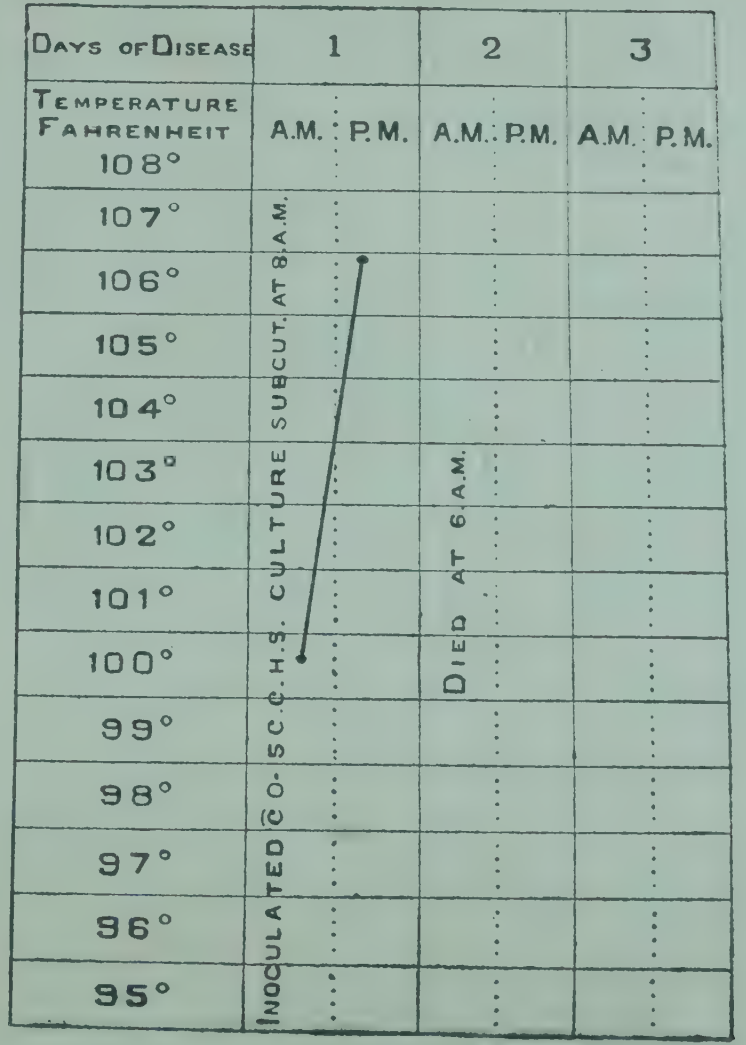
Camel No. 2. Male, 7 years old, inoculated with 2 c.c. hæmorrhagic septicæmia culture subcutaneously. Thirty-four hours after inoculation showed a very slight rise in temperature. Forty-eight hours after inoculation a slight swelling appeared at the seat of inoculation but disappeared after 2 days. The camel fed well the whole time. He was kept under observation for 7 days.



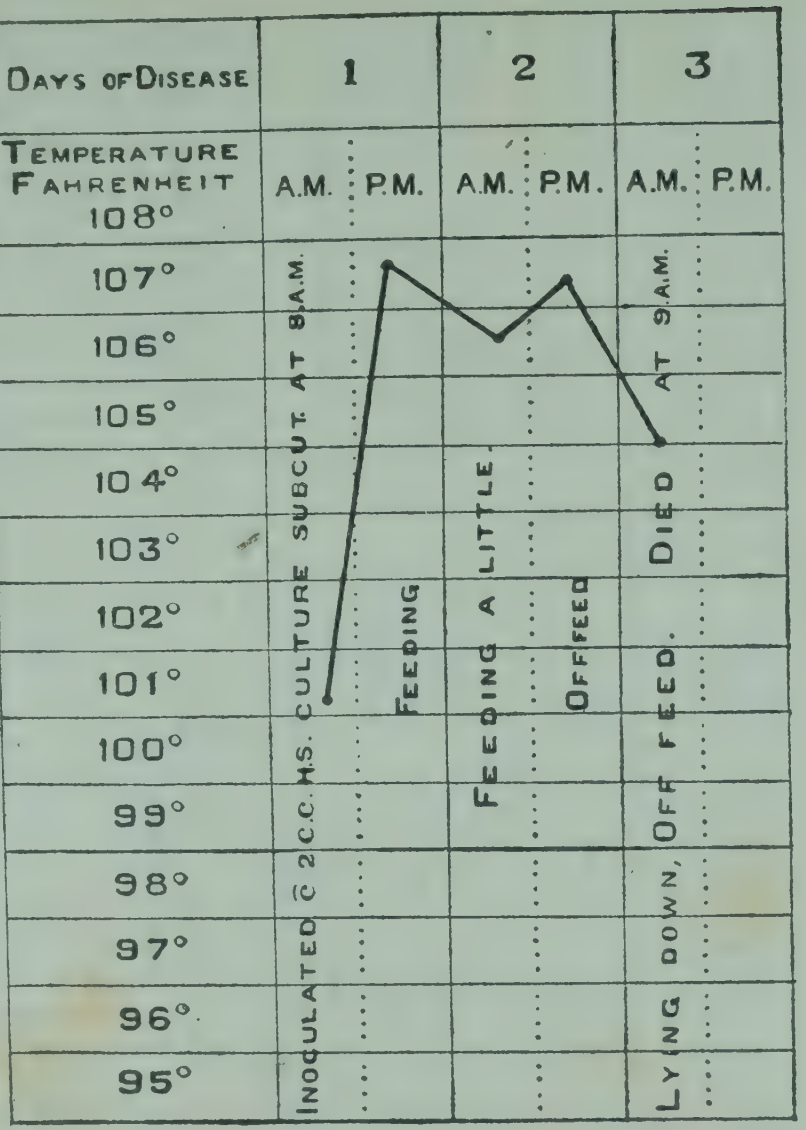
Control No. 1. Rabbit, inoculated with 0·5 c.c. hæmorrhagic septicæmia culture subcutaneously, died in 22½ hours.



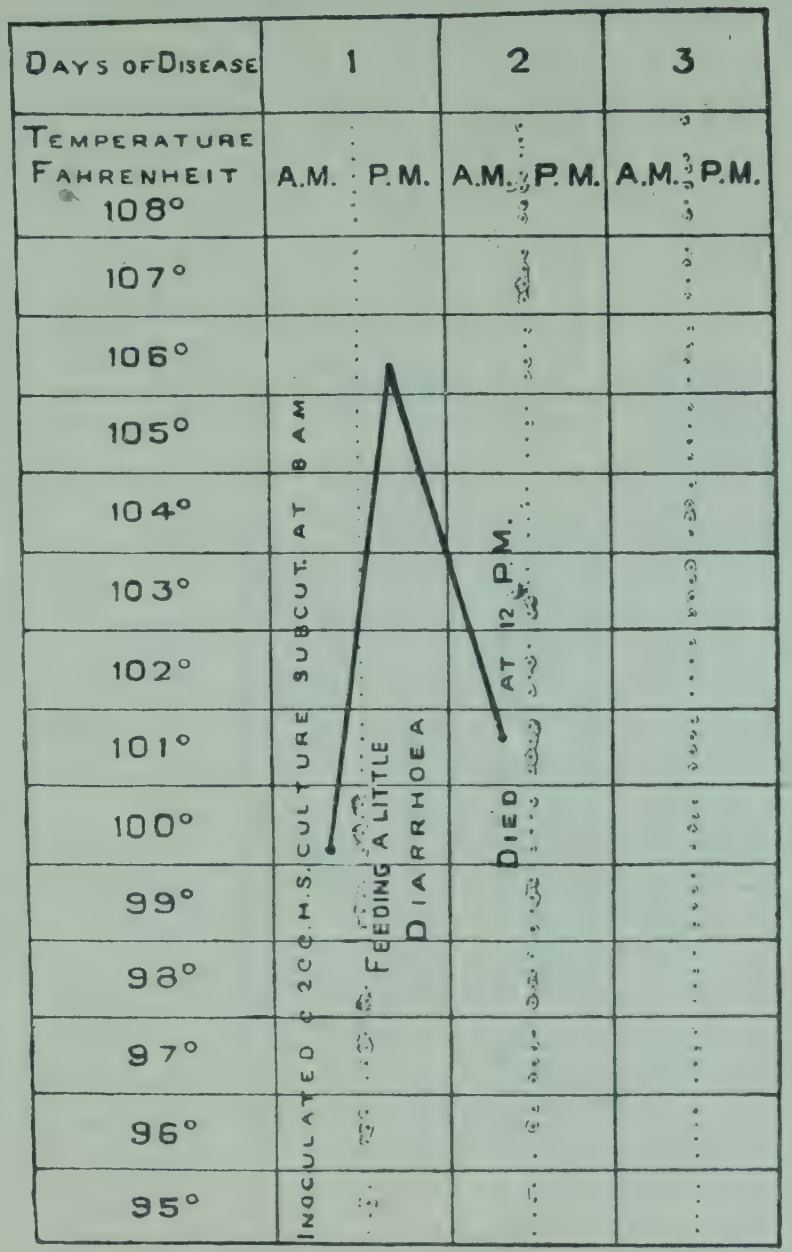
Control No. 2. Rabbit, inoculated with 0·5 c.c. of hæmorrhagic septicæmia culture subcutaneously, died in 22 hours.



Control No 3. Calf, inoculated with 2 c.c. hæmorrhagic septicæmia culture subcutaneously, died in 49 hours.



Control No. 4. Calf, inoculated with 2 c.c. hæmorrhagic septicæmia culture subcutaneously, died in 23 hours.



Gaiger's Experiments.

In this connection the experiments made by Gaiger may be of interest. They are as follows :—

Camel No. 1. Inoculated subcutaneously with 1 c. c. emulsion of hæmorrhagic septicæmia agar culture from a rabbit.

There was no apparent effect, so the animal was destroyed on the third day.

No lesions were found upon post-mortem. The control rabbit died in 15 hours.

Camel No. 2 was inoculated subcutaneously with 1 c. c. emulsion of hæmorrhagic septicæmia agar culture.

Up to the fourth day neither local nor general symptoms were shown, so the camel was destroyed, but no lesions of hæmorrhagic septicæmia could be found post-mortem, nor could the bacillus be obtained from the tissues.

Camel No. 13 was inoculated with 5 c. c. hæmorrhagic septicæmia bouillon culture five days old.

Death took place 17 hours later.

On post-mortem a bloody exudate was found in the pleural cavity.

The large intestines were inflamed.

This camel probably died from the effects of the toxin injected.

Cultures could not be obtained from the tissues or blood, so the bacilli probably did not multiply in the body.

Camel No. 7 was inoculated subcutaneously with 1 c. c. hæmorrhagic septicæmia bouillon culture 24 hours old.

There was no local reaction but the temperature rose to 104° F.

The control rabbit died in 18 hours.

Twenty-one days later the camel was again inoculated subcutaneously with 1 c.c. hæmorrhagic septicæmia bouillon culture four days old. The control rabbit died in 20 hours. There was no general or local reaction, yet 31 days later the camel died and the bacillus was obtained in culture from the internal organs.

The bacillus was much attenuated in virulence.

Conclusion. **Camels are not very susceptible to haemorrhagic septicaemia.**

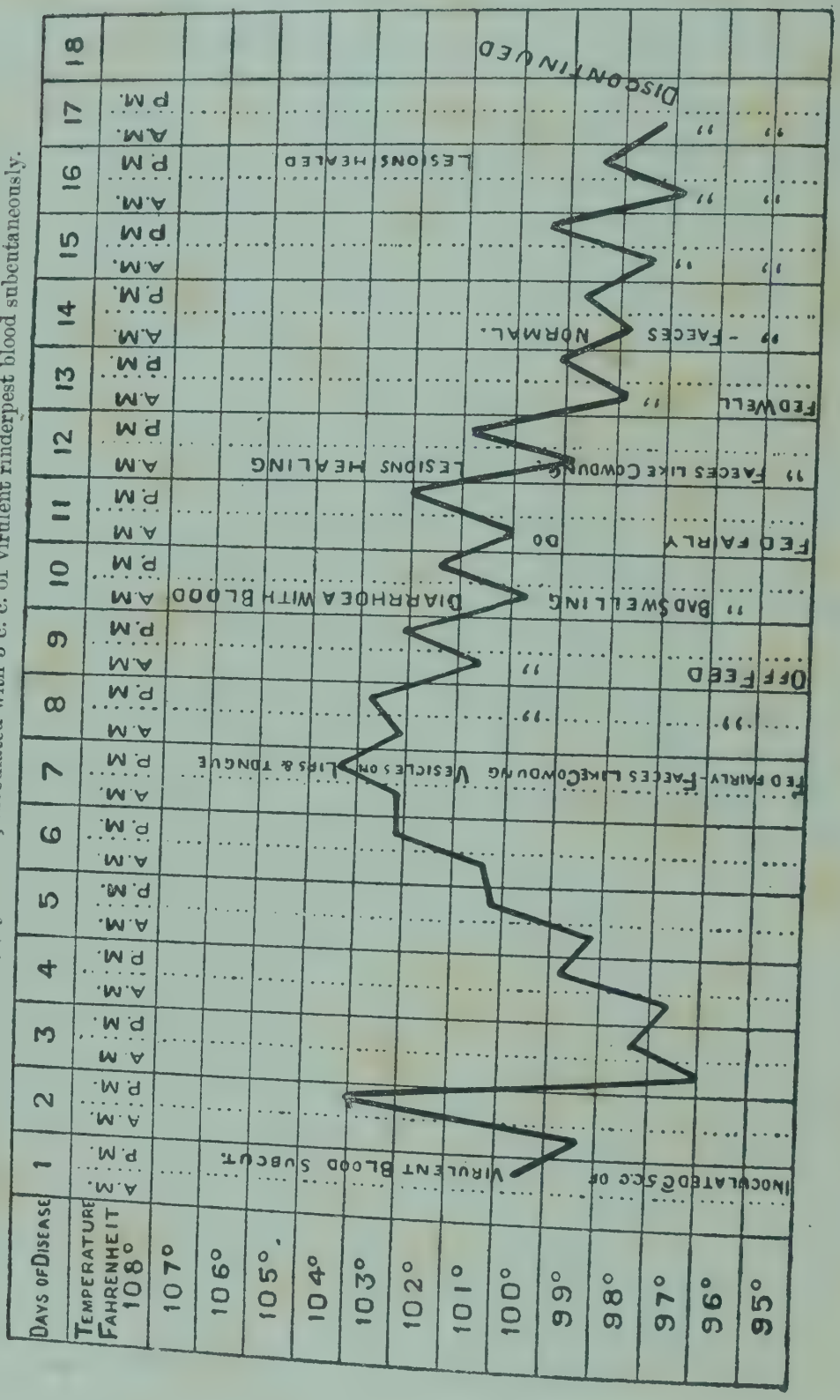
RINDERPEST.

Outbreaks of rinderpest do not take place amongst camels as they take place amongst cattle. Occasionally deaths from rinderpest are reported amongst camels, but no reliable information regarding such cases is available. To determine whether camels are susceptible to the disease, three camels (one --1 year old, one—6 years old, and one—12 years old) were inoculated with rinderpest virus, and two calves 11 months old acted as controls. The 1-year old and 6-year old camels developed typical symptoms of rinderpest, but recovered, and the third (12 years old) camel with the exception of loss of appetite, slight diarrhœa, slight temperature reaction, coughing and quivering of the muscles, developed no symptoms. The two calves which acted as controls showed only a temperature reaction and loss of appetite.

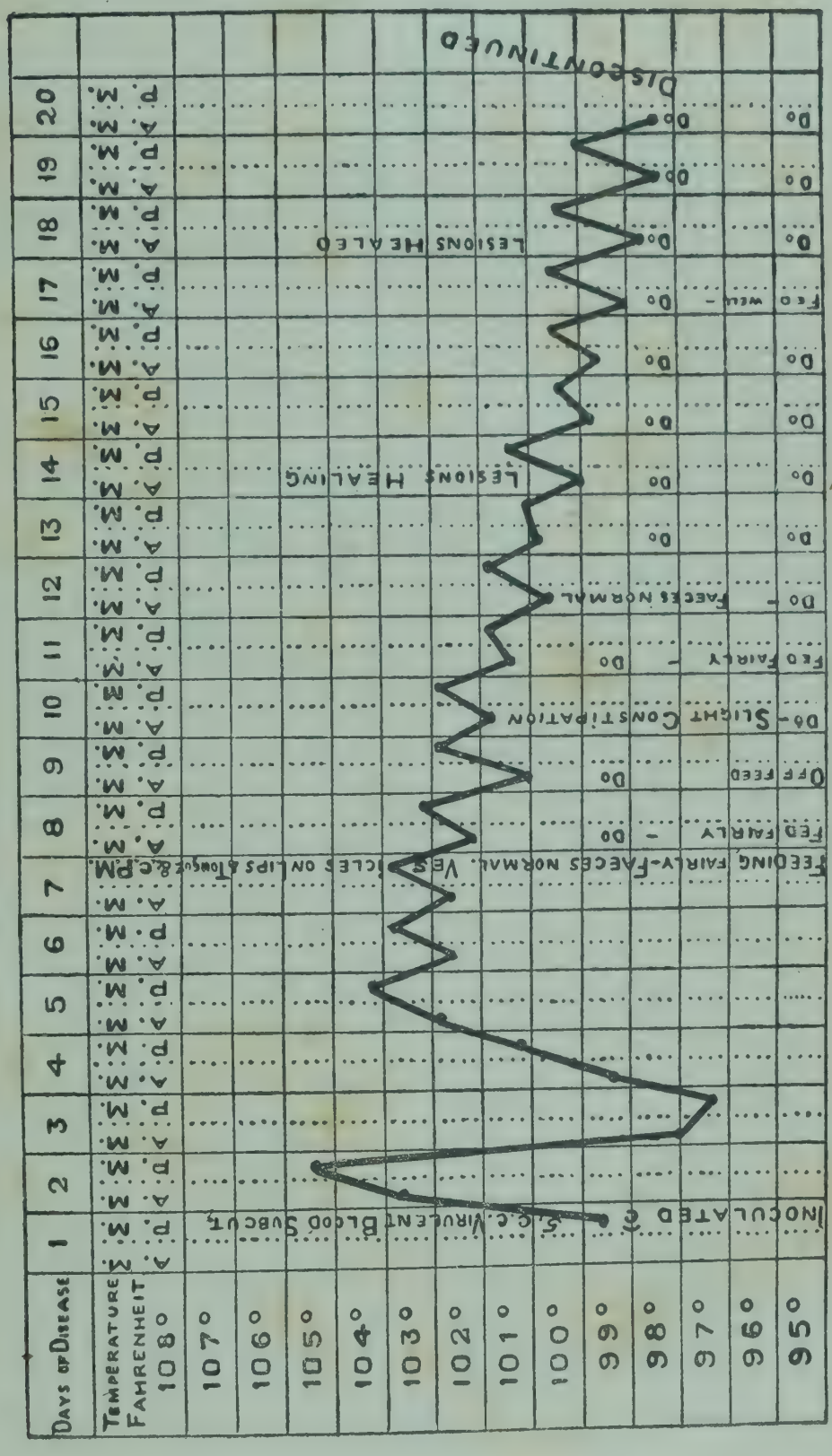
The two camels that developed rinderpest lesions presented the following symptoms :—

High fever, suspension of rumination, loss of appetite followed by trembling of the muscles, restlessness, watery discharge from the eyes, grinding of the teeth, coughing, and in the case of one camel bad smelling diarrhœa mixed with blood and mucus. On the sixth to seventh day after inoculation vesicles appeared on the inside of the lips, dental pad and tongue. On the sixteenth to eighteenth day after inoculation the lesions had healed.

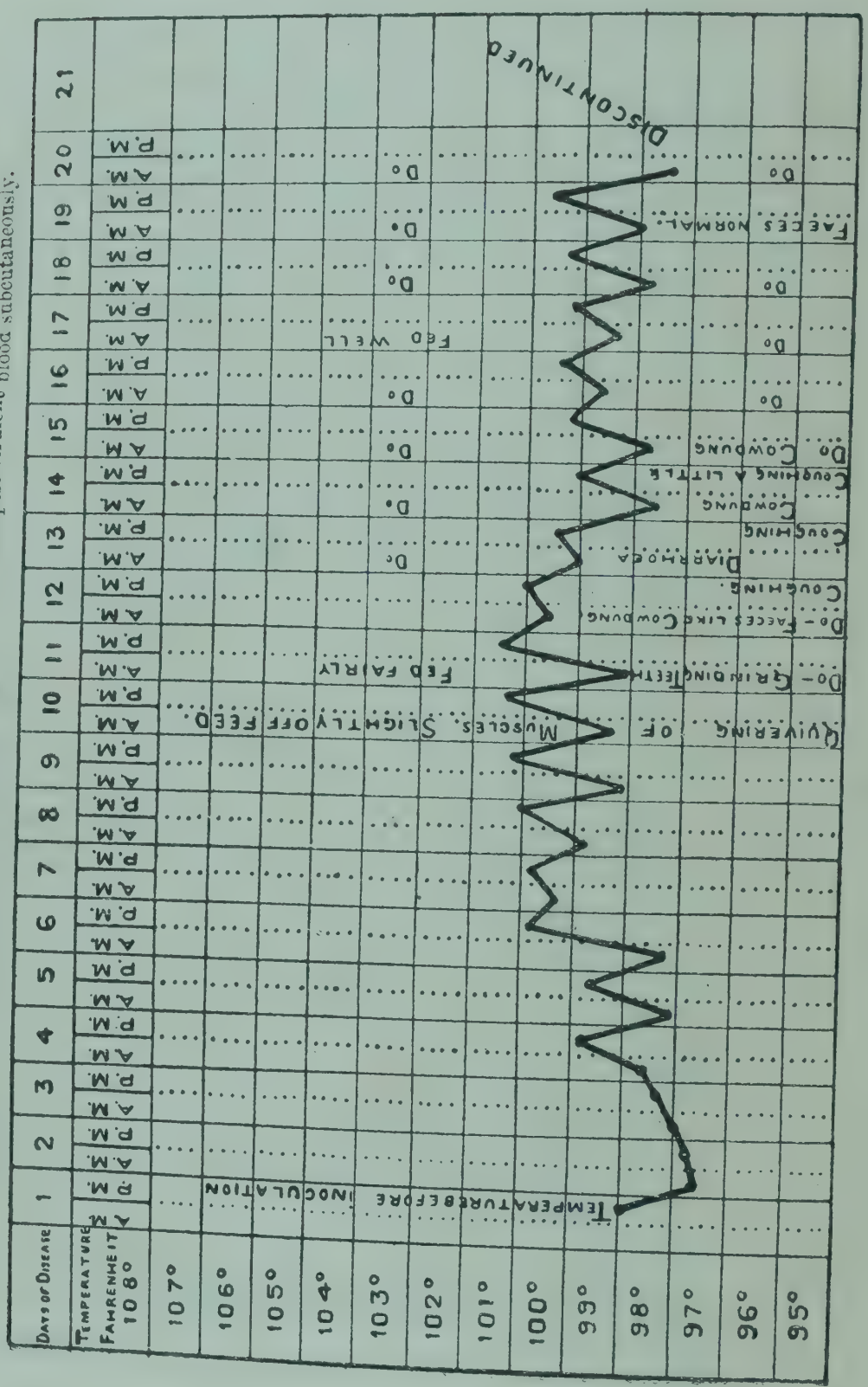
The course that the disease runs in the camel is shown in the following charts :—



Camel No. 1. Female, 6 years old, inoculated with 5 c. c. of virulent rinderpest blood subcutaneously.

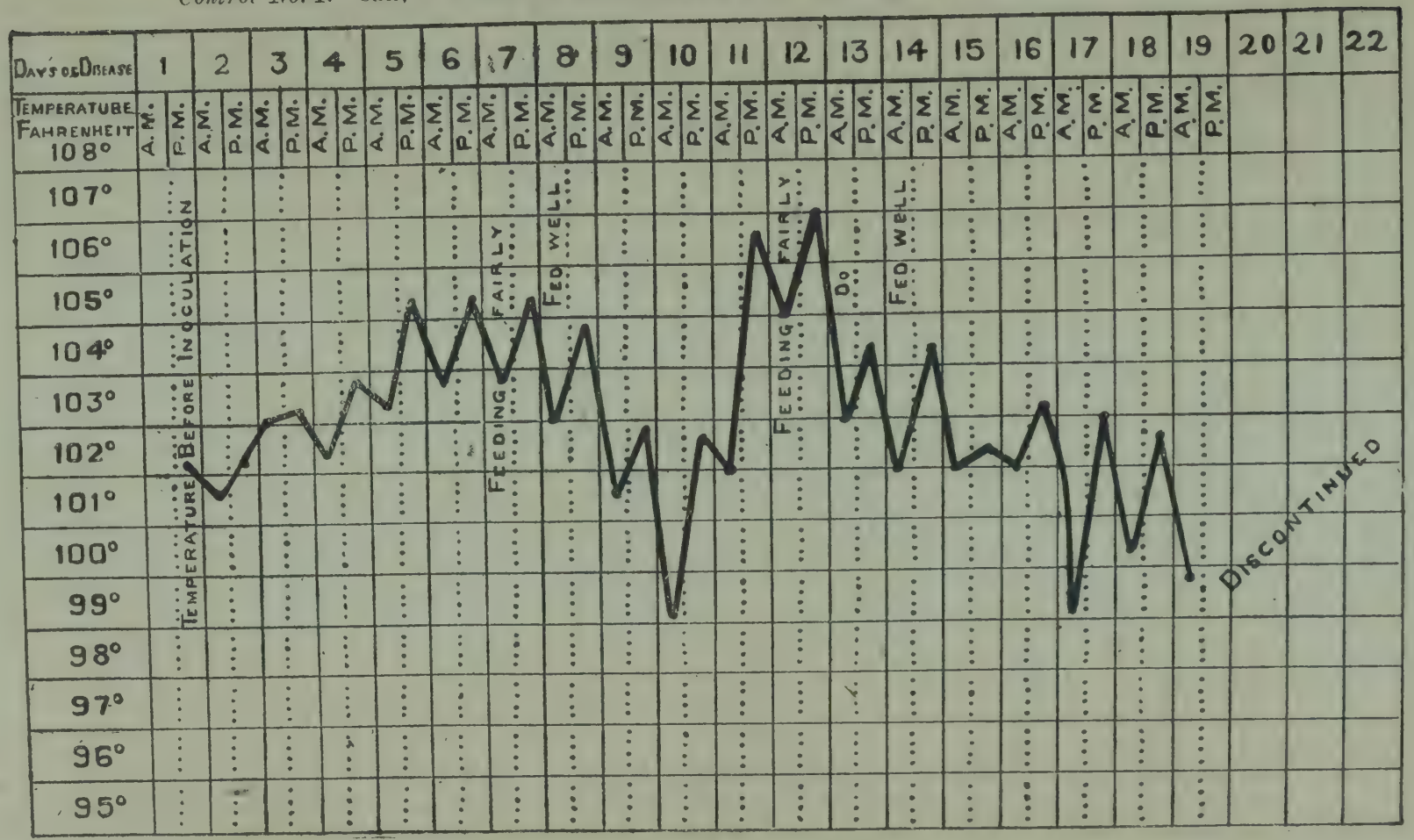

Days of Disease
Temperature Fahrenheit
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
108° 107° 106° 105° 104° 103° 102° 101° 100° 99° 98° 97° 96° 95°
A. M. P. M.
5 c. c. Virulent Blood Subcut.
Inoculated
Feeding fairly-Faeces normal. Vesicles on lips at
Feed fairly - Do
Off feed Do
Do - Slight Constipation
Feed fairly - Do
Do - Faeces normal
Do Do
Do Do
Lesions healing
Do Do
Do Do
Feed well - Do
Lesions healed
Do Do
Do Do
Do Do
Discontinued

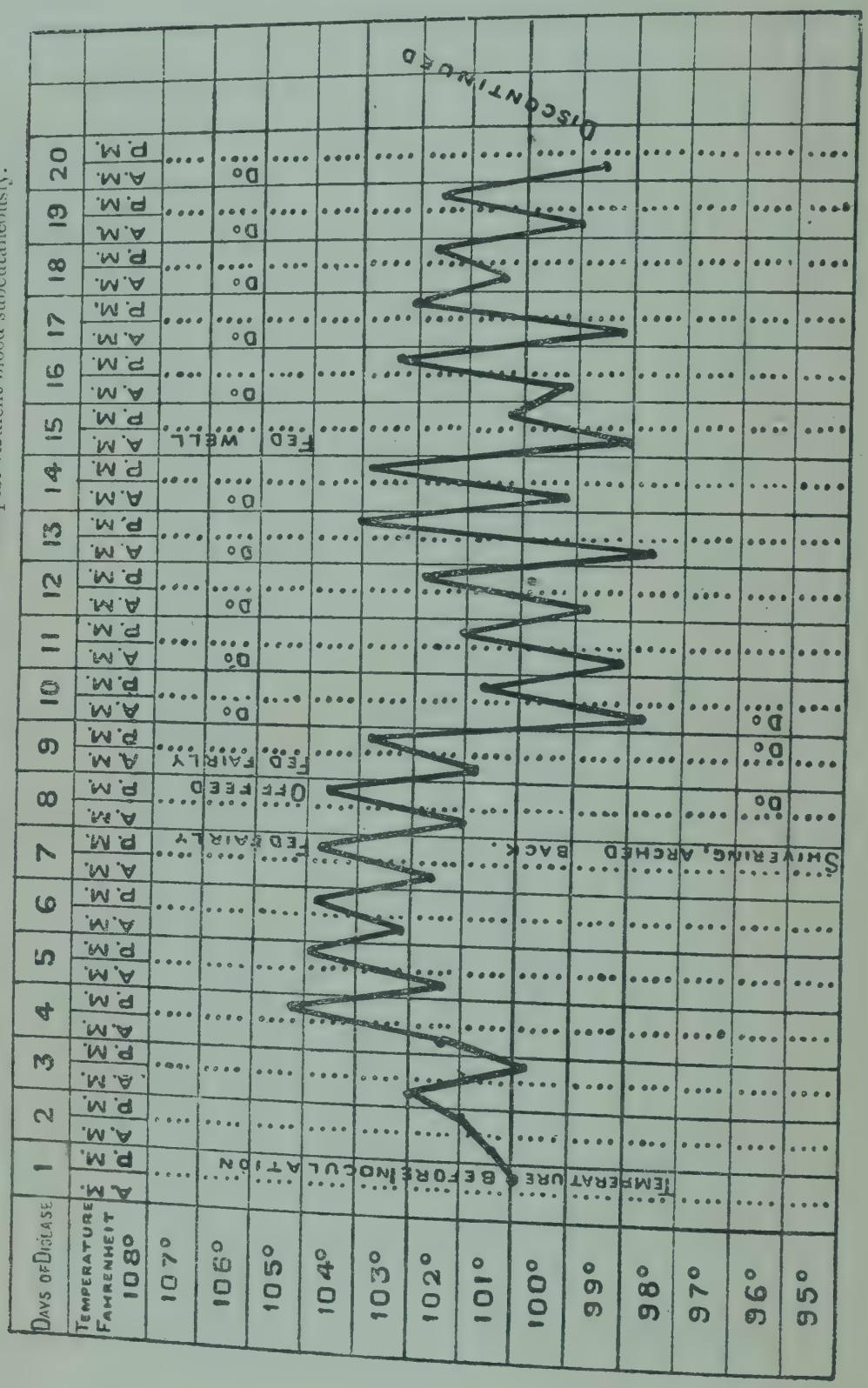
Camel No. 2. Female, 1 year old, inoculated with 5 c. c. of rinderpest virulent blood subcutaneously.



Camel No. 3. Male, 12 years old, inoculated with 5 c. c. of rinderpest virulent blood subcutaneously.

Control No. 1. Calf, 11 months old, inoculated with 5 c.c. of rinderpest virulent blood subcutaneously.





Control No. 2. Calf, 11 months old, inoculated with 5 c. c. of rinderpest virulent blood subcutaneously.

Conclusions. **The only conclusions to be drawn from the above are that camels develop severe lesions of rinderpest and are more susceptible than some cattle to rinderpest.**

This confirms the observations of Wiedornikow Petrowsky in Steppe Camels.

Introduction

THE Committee appointed to discuss this question at the Poona Meeting of the Board of Agriculture consisted of—

Mr. W. A. Davis, B.Sc., A.C.G.I., F.C.S., Indigo Research Chemist to the Government of India (Chairman).

Mr. H. A. F. Lindsay, I.C.S., Director-General of Commercial Intelligence, Calcutta.

Mr. R. S. Finlow, B.Sc., F.I.C., F.C.S., Fibre Expert to the Government of Bengal, Dacca.

Dr. Harold H. Mann, M.Sc., F.I.C., Agricultural Chemist and Principal, Agricultural College, Poona.

Mr. H. C. Sampson, B.Sc., F.H.A.S., F.B.S.E., Deputy Director of Agriculture, 5th and 7th Circles, Trichinopoly.

Mr. A. A. Meggitt, B.Sc., F.C.S., Agricultural Chemist, Assam.

Mr. C. Somers Taylor, B.A., Agricultural Chemist and Officiating Principal, Agricultural College, Sabour.

Mr. R. G. Allan, M.A., Principal, Agricultural College, Nagpur (Secretary).

Mr. R. D. Anstead, B.A., Deputy Director of Agriculture, Planting Districts, Bangalore.

Mr. E. Thompstone, B.Sc., Deputy Director of Agriculture, Northern Circle, Burma, Mandalay.

Mr. S. K. Kelavkar, Bar.-at-Law, Bombay.

Mr. A. B. Modak, Bombay.

The terms of reference were :—

To report—

(*a*) Whether deterioration of soils has been noticed in the various provinces and, if so, whether this is due to phosphate deficiency ;

(*b*) Whether the needs or the efficacy of manuring with phosphates have been noticed or enquired into ; and

(*c*) The possibility of procuring superphosphates in India at a figure which will render their application profitable to the cultivator.

The report of the Committee was as follows [1] :—

(*a*) The committee after considering the evidence available came to the following conclusion :—

The committee have not sufficient evidence before them to enable them to state definitely that any deterioration of the soil arising from depletion of phosphates has occurred generally throughout India. To decide this point experiments over a number of years would be necessary. Mr. Davis' results with indigo soils in Bihar point to actual deterioration having occurred in this area ; but for India as a whole no such evidence at present exists.

(*b*) Under the second heading evidence showed that enquiries had been made with regard to the effects of phosphatic manuring in different provinces.

In the indigo districts of Bihar such manuring is plainly beneficial.

In Bengal and Assam on the old alluvium there is ample evidence that phosphatic manuring is of value and has given considerable increase with paddy (40 per cent.), mustard and other crops. On the old alluvium lime is also deficient and is probably necessary to enable phosphates to produce their maximum effect.

On the silt alluvium evidence is variable and no general conclusion can be drawn.

Pending further investigations, on the tea garden soils evidence shows that phosphatic manures are of great value. Basic slag and basic superphosphates give the best results. Bone manures and mineral phosphate when applied to the soil have not given noticeable results except indirectly through green crops.

In the United Provinces in the eastern districts on opium soils it is possible that phosphate manuring may be useful. There is no evidence of phosphate deficiency in other areas.

In the Punjab results appear to indicate that very little benefit is at present found in the use of phosphatic manures in most of the ordinary systems of agriculture adopted in that province.

In Burma soils of the delta show great variations. In some areas the phosphate supply is ample, in others deficient. In general, however, it appears that phosphates will probably prove to be an essential manure in the great rice-growing areas of Burma.

[1] See *Proceedings of the Board of Agriculture in India held at Poona*, 1917, p. 56.

In Madras experiments with phosphatic manuring have been chiefly made with paddy. Marked deficiency in available phosphate is chiefly noticeable in old paddy soils. All forms of phosphates have yielded marked results. On the laterite high lands chiefly devoted to planting crops, tea, coffee, and rubber, paying results have been obtained by the use of basic slag and basic superphosphates.

In Bombay the need for phosphate was most felt in the rice lands of the Konkan, both superphosphate and bonemeal repaying the cost of application. Outside this area the scarcity of nitrogen and organic matter appears to be the limiting factor except possibly in the case of leguminous crops notably lucerne.

In the case of cane, phosphate alone has given poor results, but when used as a manure on a preceding green dressing crop the subsequent yield of cane was increased. Early ripening and greater purity of juice were noticed.

In the Central Provinces there appeared to be no indication of the need of phosphate in the black cotton soils. On the light soils of the province it has proved valuable in the case of paddy, sann-hemp, and cane. Experiments have not gone far enough to indicate which form of phosphate is preferable.

(*c*) At present manufacture of superphosphate in India is in so elementary a stage that no definite conclusion can be arrived at regarding the price at which it will be procurable in the future. The retail price of superphosphate before the war was Rs. 60 to Rs. 65 per ton ex-factory or port of entry.

Taking India as a whole, however, there are sufficient supplies of phosphatic manures from all sources to meet the present demands, but there are isolated localities where the question of the supply of superphosphate in the immediate future appears to be important. In these, special facilities should be considered to expedite either local manufacture or the import of this commodity.

With a view to encouraging the extended use of phosphatic manures the committee consider that a survey of the resources of the country in mineral phosphates should be undertaken by Government. In view of the vital importance to Indian agriculture of keeping the supply

of phosphates at a price within the reach of the cultivator the committee suggest that control over all the internal mineral sources of supply should be retained by Government.

The committee recommend to the attention of workers the question of investigation of forms of phosphatic manures other than superphosphate as there seems to be distinct evidence in India that the less soluble phosphates particularly in conjunction with bulky organic manures are of great value.

As the evidence submitted to the Committee seems likely to prove of general interest and of value for purposes of reference in the future, it has been decided to publish it in the form of a Bulletin.

PUSA,
28th February, 1918.

W. A. D.

Notes on the Value of Phosphatic Manures in India and the Possibility of their Manufacture on a Larger Scale.

(1)

(W. A. Davis, B.Sc., A.C.G.I., F.C.S., *Indigo Research Chemist to the Government of India.*)

In a paper read before the Indian Science Congress at Bangalore in January 1917 (Special Indian Science Congress Number of the *Agricultural Journal of India*, 1917, p. 77), I drew attention to the abnormal deficiency of available phosphate in the soils of Bihar and to the undoubted deterioration of these soils owing to their being systematically stripped of this constituent without any attempt being made to replace it. I have pointed out how this impoverishment of the soils of Bihar is also apparently responsible for a falling off in the quality of crops which leads to malnutrition of the cattle and men in certain parts of this province.

My practical knowledge of Indian soils is limited to Bihar. It seems, however, very desirable to obtain more complete information as to the phosphate requirements of the soils of other provinces, the efficacy of manuring with phosphate, and the desirability of arranging for the manufacture of superphosphate in India on a larger scale than has been carried out in the past so as to diminish the cost of this fertilizer. There is no doubt that the present practice of exporting large quantities of oil-seeds to Europe to be pressed there is gradually stripping many Indian soils of their fertility in an alarming way and that the yield of such oil-seeds and other crops in many parts of India could be increased by proper phosphatic manuring. Discussions by the agricultural officers of the different provinces should be invited on these points, particularly as regards any signs of deterioration of soils or the needs of phosphate as a manure that may have come to their notice.

There is, I think, little doubt that the deficiency of one single constituent in a soil leads to the spread of fungal or insect disease in crops. This is well shown on the experimental plots at Rothamsted, and Mr. Andrews, Entomologist to the Tea Association, has recently stated (*Journal of Indian Tea Association*, 1915, p. 107) that incorrect manuring

will often lead to a sickly condition of the bush and render it unable to throw off the attack of insect pests.

The present price of superphosphate in India is very high and a large proportion of the fertilizer has to be imported. It is very desirable that larger quantities should be manufactured in India.

There is one aspect of this question which I should like to emphasize. If larger quantities of superphosphate were required it would lead to an increased output and diminish the cost of production of sulphuric acid, the high price of which in India at present prohibits its use in many industries.

Deterioration of the indigo soils of Bihar.[1]

In 1907 Dr. Leather pointed out that, judged by analysis, the soils of Tirhut were in a dangerously depleted condition as regards available phosphate. In Muzaffarpur District 40 per cent., in Saran 60 per cent., in Darbhanga 75 per cent., and in Champaran 80 per cent. of the soils examined at Pusa in 1907 contained less than 0·0007 per cent. of available phosphate.

Since that date practically no attempt has been made by planters to remedy the condition of their soils by proper manuring, and it has not been realized that the gradual and increasing failure to obtain second cuttings of indigo and the almost complete impossibility of obtaining Java indigo seed have been due to a steady and continuous impoverishment of the soil. This year (1917) a large number of analyses have been made of the soils of indigo estates, and it has been found that they are now in an even worse condition than in 1907 : many of the soils contain less than 0·0002 per cent. of available phosphate, whilst in several not even a trace of available phosphate can be detected. In the latter soils crops die out shortly after germination, owing to starvation.

There has been a rapidly increasing failure of indigo crops of recent years, the progressive character of which may be judged by an example taken from the experience of one factory (Belsand) at which data have been preserved. Between 1904 and 1908 there was no pronounced failure of the leaf crop of indigo, but that the soil was deteriorating rapidly is shown by the steady falling off in the seed yield of the Java indigo plant the first sign of phosphate starvation.

	Yield of indigo seed per acre
1905-1906	15 maunds.
1906-1907	8 "
1907-1908	"Yield" disappointing."
1909	"Very poor" (less than 2 maunds).

[1] See "A study of the indigo soils of Bihar," by W. A. Davis. *Indigo Publication No. 1, Agricultural Research Institute, Pusa.*

In 1909 the green plant itself began to fall off and the *khoonties* (second cuttings) to fail more or less completely. In later years the first cuttings also began to deteriorate in quality and quantity, until in 1912 there was a falling off of 65 per cent. of indigo as compared with the yield in 1908.

In 1908 total produce of cake indigo 604 maunds from 1,334 bighas.
„ 1912 „ „ „ „ 220 „ „ 1,470 „

At the present time the majority of the Bihar indigo soils are so impoverished that they regularly fail to give seed crops of indigo, whilst on most estates *khoonties* are no longer obtainable. This is especially the case in Champaran, where at some factories (*e.g.*, Byreah, Mullayah) *khoonties* have not been obtainable at all for several years, the amount of phosphate in the soil barely sufficing to give a single cutting.

This year (1917) the failure of the *khoonties* has been general, and, in consequence of this, although the area under indigo was increased by 12 per cent. as compared with last year, the indigo crop is estimated to be 5 per cent. lower than last year, that is a falling off in all of 17 per cent.

Year	Area (acres)	Yield (cwt. of 60 per cent. indigo)
1916-1917	76,500	10,800
1917-1918	85,900	10,300

The failure is all the more remarkable because at most factories the climatic conditions were more favourable than last year : there was less rainfall during the actual months of *mahai* (June, July, and August) and less loss from flooding. The position is a very serious one, and unless steps are at once taken to remedy the deterioration of the soil by manuring with superphosphate, it seems certain that within the next few years there will be a widespread and increasing failure of indigo crops similar to that which occurred at Belsand between 1908 and 1912.

Soil deterioration affecting other crops.

That the lack of available phosphate in Bihar soils causes low yields of other crops is clear from the data showing the effect of phosphate manuring given in the paper referred to above. It is also very strikingly brought out by considering the low yield of opium between the years 1900 and 1907 for certain districts of Bihar as compared with districts further west, especially in the north-western portions of the opium area. The following average returns are taken from Messrs. Oakden and Butler's "*Note on the Opium Question*" (March 31, 1909, p. 43).

	Average annual yield of opium per bigha, seven years ending 1906-1907	
	Seers	Ch.
Bihar—		
Muzaffarpur District	3	15
Darbhanga ,,	3	15
Saran ,,	3	13
Champaran ,,	*2*	*6*
Patna ,,	3	14
Monghyr ,,	3	3
United Provinces—		
Ghazipur District	3	15
Ballia ,,	4	1
Allahabad ,,	4	7
Fatehpur ,,	4	7
Farrukhabad ,,	5	2
Cawnpore ,,	5	2
Mainpuri ,,	5	2
Bareilly ,,	5	7
Budaun ,,	5	10
Bara Banki ,,	5	10

It was pointed out in the report by Messrs. Oakden and Butler referred to, that "the areas of low yield are clearly defined and *comprise the whole of Bihar* and the eastern and submontane districts of the United Provinces, *viz.*, the districts of Ballia, Ghazipur, Benares, Mirzapur, Jaunpur, Azamgarh, Gorakhpur, Basti, Gonda and Bahraich. *Westwards the yield increases* and it reaches its highest limit in the Rohilkhand Division at the north-west extremity of the opium area—Budaun, Bareilly and Shahjahanpur being the most important districts."

It seems more than a mere coincidence that by far the lowest yield of opium for the seven years ending 1906-1907 was obtained in the Champaran District of Bihar where in 1907 the so-called wilt disease of indigo first appeared (at Mullayah) and where the yields of indigo, owing to failure of *khoontie* crops, are at the present day worse than elsewhere in Bihar. It was in Champaran, too, that analysis showed the soils to be far more depleted of phosphate in 1907 than those of other districts of Bihar, and the same holds true to-day. There is no doubt that the gradual improvement in opium yield passing westward from Bihar into the United Provinces follows a gradual increasing content of the soil in available phosphate, until the high yielding areas (Cawnpore, Bareilly, etc.) are reached, which are known by analysis to be rich in available phosphate. It would appear that by phosphatic manuring the yield of opium in districts such as Ghazipur, Ballia, etc., could be considerably increased.

(2)

(C. SOMERS TAYLOR, B.A., *Agricultural Chemist to the Government of Bihar and Orissa.*)

There are one or two points in Mr. Davis' note to which I wish to draw attention.

Firstly, as regards the impoverishment of soils in Bihar. This abnormal deficiency of phosphate, available as well as total, has long been known and a considerable amount of work was done upon it by Dr. Leather at Pusa in the early days of the Department.* I gather that Mr. Davis in referring to Bihar, more especially refers to Tirhut as that is the area upon which I understand he is working. Such work as I have done on the soils of this province would indicate that the soils to the south of the river Ganges are in the main also very deficient in this constituent, particularly the laterite soils of Chota Nagpur and Orissa. (This of course does not apply to such soils as have been artificially or naturally manured.) As striking instances of such deficiencies in phosphate, I may quote the following analyses of soils in tabular form:—

Soil No. of samples	Mean available phosphate	Standard deviation of series from mean
	per cent.	
Ranchi farm, 2	0·002	..
Cuttack farm untreated with phosphate, 14 . .	0·005	+0·0008
Cuttack farm treated with phosphate, 16 . .	0·007	+0·0011
Unmanured soils in the neighbourhood of Cuttack farm, 20.	0·0038	+0·0018
Khurda Sub-division, 19	0·002	—0·0017

I have other data and am still collecting information as to the requirements of soils from different parts of the province, but the majority of soils which I have examined up to the present have shown an amount of available phosphoric acid far below that usually considered in Europe to be necessary for a satisfactory plant growth.

I may mention that the series of analyses from Cuttack was undertaken in connection with the appearance of a peculiar disease which was appearing in the rice crop and that the figures of my analyses have been for some time in the hands of the Deputy Director of Agriculture, Orissa Division.

* This work has been referred to in my paper on the "Phosphate depletion of soils of Bihar" in the *Agri. Jour. of India* and more fully in *Indigo Publication No.* 1. [W. A. D.]

It is obvious, however, that no increase will appear in the consumption of phosphatic manures until their use has been proved to be profitable, and such results as have been published on the subject from the Cuttack farm do not indicate profit from the use of phosphatic fertilizers. It will, however, be noticed that these soils of the Cuttack farm show a distinctly higher percentage of available phosphoric acid than the soils of Ranchi or Khurda. It is possible that, under the different conditions of India, we may have largely to revise our ideas as to the minimum amount of available phosphoric acid necessary for plant growth, and that an amount of 0·004 or 0·005 may be ample for the needs of the rice plant.

I have not quoted figures for the Sabour soil, as nearly the whole of Sabour farm is amply provided with phosphoric acid. The Ranchi farm is the farm under the Bihar Government which shows most strikingly a lack of available and total phosphoric acid, and certain experiments are I understand, being carried out on the effects of phosphates upon the soil of that farm. These experiments are being carried out by Mr. Dobbs in connection with the "Tikka" disease of groundnut, with a view to determining whether this disease may be successfully combated by the plant when properly fertilized. This is of interest in view of Mr. Davis' remark as to the spread of fungal disease in badly nourished crops.

As regards the present price of superphosphate the problem is a very difficult one. There is no doubt that it is desirable that larger quantities should be manufactured in India, and every practical man has long been convinced of the advantages which would accrue if sulphuric acid could be made cheaply in India. I doubt, however, whether the cost of production of this acid could be very much reduced under present conditions.

One of the great drawbacks, if not the great drawback, to this manufacture in this country is the absence of easily accessible sources of cheaper sulphur. In England the commerical acid is exclusively made from iron pyrites, while in India the acid is made from imported sulphur. The pyrites are found on or near the spot in England, and, in consequence, the price of production is enormously lower in England than in India. Mr. Tutwiler, the Manager of Messrs. Tata's works at Sakchi, has kindly informed me that in normal times the cost price of sulphuric acid of 1·6 sp. gr. manufactured by his plant is Rs. 75 per ton while in normal (pre-war) times in England the cost was only £2 per ton. To increase the size of the plant will of course reduce the cost, but it can hardly be brought down to as low a cost as in England where pyrites is both abundant and easily accessible. It is of course cheaper to make

the acid than to buy it, but very careful calculations would have to be made before we could see how much less it would cost to make Indian superphosphate than to import it from Japan as is being done at the present time.

Finally, a large and steady demand for superphosphate would have to be created before any progress could be made in increasing the quantities manufactured. The knowledge of the value of superphosphate in conjunction with green-manuring in the Tirhut area is not by any means a new thing. When I arrived in India in 1907 experiments were being carried out by Dr. Leather on the effect of superphosphate on certain crops. Increased yields were obtained, and I believe that the results were placed by Dr. Leather before the Bihar Planters' Association. If superphosphate could be obtained cheaply there can be no doubt that its use would be of great use in the Tirhut area where it has long been used in conjunction with green-manuring by many scientific agriculturists.*

It still remains to be proved, however, that its use will be profitable outside this area, and it is possible that the constitution of the laterite soils of South Bihar and Orissa is such as to necessitate a more basic compound than superphosphate. The problem is, however, in its infancy, and our knowledge of the value of superphosphates on the soils of this province is hardly in such an advanced state as to warrant the sinking of large sums of money in sulphuric acid plant purely for the manufacture of superphosphates.

There can, however, be no doubt that it is high time to take steps to develop our knowledge in this direction. The examples I have given of various typical soils of this province show that phosphoric acid is notably poor in quantity over large areas. A soil survey for phosphoric acid content is one of the first essentials, and this should be taken in hand at once. The survey should be made of the large river basins in Bihar and Orissa as practically the whole of the soils of these two divisions of the province are alluvial, and their character will be largely determined by the character of the rocks at their head waters.

Experiments should be made in the various areas found to be deficient, and, if they are financially successful, there is no doubt that a demand will at once be created. Until this demand has been created, however, it is doubtful whether a commercial man would look at any project for making large quantities of superphosphate in India. It is for the Department to create this demand after carefully finding the best method in which the fertilizer may be used.

* My enquiries among the planters show that up to the present time, only two or three of the planters have even experimented with superphosphate. All the available cases are referred to in *Indigo Publication No. 1.* [W A. D.]

(3)

(B. C. Burt, B.Sc., F.C.S., *Deputy Director of Agriculture, Central Circle, United Provinces.*)

The only information I have about superphosphate is that it yields satisfactory results in connection with green-manuring for wheat. I have no evidence that the soils in any part of my Circle are particularly deficient in phosphate, and, as far as field experiments on wheat at Cawnpore go, this does not appear to be the case. I cannot hold out any hope that there will be any demand for superphosphate on a large scale in the United Provinces at present.

(4)*

(S. Milligan, M.A. B.Sc., *Offg. Director of Agriculture, Bengal.*)

Soil Improvement. There are two very distinct classes of soil in the province: (*a*) The laterite or old alluvium; (*b*) The silt or new alluvium. There is a general lack of carbonate of lime and phosphates in both. The laterites, however, are much more acid than the silts, and consequently respond more readily to basic phosphatic manures like bonemeal. On the other hand, potash, which is deficient in the laterite soils, is present in sufficient and sometimes large quantities in the silts. A soil survey is in progress and is at present confined to a chemical examination of soil samples. Demonstration work is, however, being continued in West Bengal on the laterite soils with bonemeal, where satisfactory results have already been obtained.

On similar soils in East Bengal both lime and bonemeal have given results of economic value, and it is proposed to attempt the extension of the use of these manures through co-operative societies.

It has been definitely proved that the application of potash manures for jute on laterite soils yields a profitable increase and at the same time acts as a preventative against the fungus disease *Rhizoctonia*. The water hyacinth (*Eichornia crassipes*), which grows in abundance in low-lying tracts of the province, has been found to be a valuable source of potash. It is proposed to carry out demonstrations of the use of the ash of this plant on laterite soils.

(5)

(O. T. Faulkner, B.A., *Deputy Director of Agriculture, Lyallpur, Punjab.*)

The results appear to indicate that very little benefit will accrue from the use of phosphatic manures in most of the ordinary systems of Punjab

* Extracted from the Programme of the Department of Agriculture, Bengal, 1918-1919.

agriculture. Some of the experiments referred to in this note might be adversely criticized; but their consistently negative, or practically negative, results must lead towards the conclusion that there are factors in our conditions in the Punjab canal colonies which make the effects of phosphatic manures very much less beneficial than in England.

(I) Experiments in square 27 at Lyallpur farm.

The experiment was rather elaborate and involved the use of a large number of different artificial manures. There is also little doubt that the unmanured strips are too narrow and are probably affected by the manures diffusing in from the adjoining manured plots. Great weight cannot therefore be attached to these results; but the fact that such slight differences in yield are apparent after the annual application of these manures to these same plots for six years, suggests that they can have had no very great effect. A new experiment which we trust is better designed has been started in place of this.

These experiments are explained and the results given in detail in the Appendices to the Annual Reports of the Department as follows:—1912, page iv and pages xxiii to xxvi; 1913, xvi to xix; 1914, xiv and xv; 1915, xxxii and xxxiii; 1916, xxi to xxiii.

(II) The experiments referred to in I having given negative results but being so open to criticism, the series was started of which the results are given at the references below. The design of these experiments cannot, I think, be very adversely criticized. The land was carefully selected: the plots are large enough, there are sufficient repetitions and plenty of controls. Any differences in yield observed are, as will be seen, mostly well within the probable experimental error, whilst the differences between similar plots indicate that the results seem to be reliable. One figure only calls for comment—the apparent negative or rather depressing effect of farmyard manure on *toria* (*B. campestris* var. *Napus*) in 1916-17. That the effect should be negative is not, I think, remarkable, for considering the extremely short, cool growing season of the *toria* crop it could only be expected to take advantage of the very readily available ingredients in the manure. It is generally considered by zemindars that manure applied to *toria* chiefly benefits the following cotton crop. The apparent depressing effect of the farmyard manure, if it represents anything more than experimental error, may be due to some secondary effect. None of the land at Lyallpur has yet been under cultivation longer than since the beginning of this century, though it seems to have settled down to a fairly steady level of productivity.

For abstract of experiments see pages 42 and 43 of Handbook[1] and 1916 Annual Report, Appendix, pages xxxi and xxxii.

(III) At Gurdaspur experiments with phosphatic manures have been carried out regularly for several years on the same plot in the *barani* (depending upon rain water) area, on land which has been under cultivation almost certainly without manuring for many years. For the first few years the phosphatic manures showed no important effect on the yields and the financial results were a loss. Now, however, that the residues have been accumulating for several years, there are slight differences in favour of the phosphatic manured plots, and thus the annual results apparently show very little economic loss or a slight profit. It might be mentioned that at a certain stage the wheat on phosphatic manured plots appears to be ripening ahead of the controls ; but the actual date of final ripening is very little affected.

(IV) There have been experiments made at times on the *chahi* (well irrigated) area at Gurdaspur as, *primâ facie*, there is more possibility of profits from manures on such land. The results of some of these have been more encouraging ; but in many other cases yields of the manured plots have been less than, or equal to, the controls. As a matter of fact the land on which these experiments have been tried is far too rich and variable for any very marked results to be expected. The question of phosphatic manuring on *chahi* land is one in which investigation will probably be continued and extended when suitable land becomes available.

(V) Experiments have also been started at Gurdaspur on the use of phosphatic manures in addition to green manures and farmyard manure. So far the phosphatic manures do not appear to have given any result ; but the experiments have not been carried sufficiently far to be conclusive.

The Gurdaspur results are given in appendices to Annual Reports as follows :—

Experiments on barani *land.*

1914	Statement 5, page xxvi.
1915	,, 3 ,, xlvii.
1916	,, 5 ,, xli.

Experiments on chahi *land.*

1915	Statement 4, pages xlviii & xlix.
1916	,, 4 ,, xl & xli.

To summarize :—

In the canal colonies, under ordinary systems of cropping and cultivation, phosphatic manures have not paid up-to-date. But the land

[1] *Experiments, etc., at the Agricultural Station, Lyallpur, Punjab,* 1917.

has not been under cultivation very long. It is possible that artificials might pay under a system of intensive cropping, which would allow of a minimum of fallow cultivation. Experiments to test this here are only now being started at Lyallpur. But as such a system does not and cannot be introduced in the canal colonies in the present circumstances (as to irrigation and economics), the results will be of theoretical rather than of practical importance for the present.

Under *barani* cultivation in Gurdaspur artificial manures have not been profitable. On *chahi* land the experiments are not conclusive, but a consideration of the results obtained and general factors leads one to the conclusion that though the possibilities in connection with artificial manures on *chahi* land are no doubt worth investigation, yet there is not nearly such a hope of improving our crops by this means as there is in many other directions.

(6)

(G. D. Hope, Ph.D., B.Sc., F.C.S., *Chief Scientific Officer, Indian Tea Association, Calcutta.*)

The experience I have had in the manuring of tea estates in North-East India, which extends over the last ten years, makes me think that phosphatic manures are of very great value on most tea soils. Basic slag and superphosphate give the best results; bone manures and mineral phosphates, when applied directly to the soil and not for the purpose of promoting a green crop, have not given noticeable results. It is usual now to use phosphatic manures largely to manure green crops, which are grown in the spring and are hoed in after six weeks' growth; the plants used for this purpose usually being various species of *Phaseolus*, *Sesbania*, and latterly cowpeas.

Careful experiments have been carried out on soils in the neighbourhood of Tocklai Experimental Station near Jorhat in Assam, using various phosphatic manures, and as the result of six weeks' growth of cowpeas it was found that basic slag and superphosphate gave similar results which were very considerable, and steamed bonemeal was the next most successful manure, while rock phosphate derived from Egypt gave rather poor results, but all the experiments showed the value of these phosphatic manures. Similar experiments have now been carried out on soils which differ slightly from that on which the first experiments were made. They all demonstrate the great value of phosphatic manures, particularly when used on land which has recently been under grass.

The total phosphoric acid in the soils of North-East India ranges from about 0·3 per cent. to a mere trace, but the usual minimum is about 0·04 per cent. and the soils on which less than that has been found are few. The amount of available phosphoric acid as measured by the amount extracted from a soil by 1 per cent. citric acid solution is usually about 0·01 per cent. to 0·02 per cent. but is often lower. There are, however, certain soils of fairly recent origin which are now being chemically investigated, in which available phosphoric acid is as high as 0·09 per cent. In the soils which are older geologically the amount of available phosphoric acid, as determined by the citric acid method, is usually less than in those more recently formed. Few tea soils have large percentages of carbonate of lime. Consequently the presence of lime interferes but little with the determination of citric-acid-soluble phosphoric acid.

In view of the comparative cheapness of the unit of phosphoric acid when purchased as bones, an endeavour will be made by those working in the interests of the North-East Indian tea industry to understand how the best manurial value can be obtained from bones. When this has been worked out in regard to the different types of soil and climate, bones will probably be the class of manure most chiefly used, particularly in consideration of the fact that tea being a perennial crop rapidly acting manures are not usually required, if manuring be done in a systematic way. However, there is likely always to be a considerable use for basic slag and superphosphate on tea estates if these drop to a reasonable price. The tea industry will be a good customer to any one willing and able to put good superphosphate on to the Indian market at a reasonable figure.

(7)

(W. H. Harrison, D.Sc., *Government Agricultural Chemist, Coimbatore.*)

During the past ten years manurial experiments with phosphatic manures have been carried out on most of the experimental farms in Madras, and the result has been to demonstrate the fact that there is a fairly general need for this form of special manuring. The soil surveys of the Tanjore, Guntur, and Kistna deltas also support this conclusion, and the permanent manurial plot on the College farm has shown that phosphoric acid starvation is felt the earliest in the dry soils. There is, in addition, a growing demand for phosphatic manures from the planting community based upon the result of past experience.

Unfortunately from the point of view of manufacturing superphosphate in South India, the sulphuric acid necessary must either be imported or else manufactured from imported raw materials, which

militates against cheap production, and, in addition, the available supply of raw phosphate is limited to Trichinopoly phosphates and bones. The Trichinopoly phosphates are of low quality as they contain excessive proportions of iron and alumina, but their worst feature is the large amount of carbonate of lime (up to 20 per cent.) they contain, which leads to an unduly large consumption of sulphuric acid in the process of manufacture into superphosphate and practically throws them out of court.

Apart from Trichinopoly phosphates the only indigenous supply of raw phosphate is bones, and as a matter of fact bone super and bone char super are manufactured in this presidency, so that this raw material will necessarily be the basis of any extended manufacture in the immediate future. Fortunately the supply is considerable and ample.

Considering the subject as a whole, I feel that the main difficulty lies in the production of sulphuric acid cheaply and abundantly, and it is to this aspect of the problem that attention must be mainly directed.

[For an instance of marked phosphorus starvation in Madras Presidency see R. C. Wood, *Year Book of Madras Agricultural Department*, p. 112. For the results of manurial trials with phosphates on sugarcane see the *Reports of the Samalkota Agricultural Station*, 1906-1907 to 1909-1910, and the *Report of the Coimbatore Agricultural Station*, 1911. 1912. W. A. D.]

(8)

(H. C. Sampson, B.Sc., F.H.A.S., F.B.S.E., *Deputy Director of Agriculture, V and VII Circles, Trichinopoly, Madras Presidency.*)

With reference to this subject I wish to point out that the third term of reference presupposes that superphosphate is likely to be the main form in which phosphatic manures are to be applied and appears to neglect other forms of phosphatic manures.

Recent work, both in America and in the Madras Presidency (*vide* Reports of Manganallur Agricultural Station), clearly shows that otherwise "insoluble" phosphates become readily available when applied in conjunction with green manure, and the point to aim at seems to me to be not so much whether we can cheapen and increase the quantity of superphosphate but rather whether we can make more effective use of the cheaper forms of phosphatic manures already available in the country.

Apart from phosphatic manures of organic origin, there are large deposits of low-grade phosphate in Madras (containing 57 per cent. tricalcic phosphate, 17 per cent. calcium carbonate, 7 per cent. iron and aluminium compounds) which are unsuitable for the manufacture of

superphosphate unless sulphuric acid can be produced at a very low cost.

(9)

(RUDOLPH D. ANSTEAD, B.A., *Deputy Director of Agriculture, Planting Districts, Bangalore.*)

The experience I have had regarding the use of phosphatic manures as applied to tea, coffee, and rubber leads me to believe that they are of very great value on most of the types of soil which occur in South Indian planting districts. Finely ground bonemeal has been extensively used for many years by coffee planters in conjunction with poonacs, but basic slag and basic superphosphates give the best results especially when their application is followed by a green dressing crop such as *Crotalaria.*

Owing to the lack of established experiment stations no really reliable experiments have been carried out from which figures can be quoted, but in a series of rubber manurial experiments now being conducted on an estate the value of basic slag and mineral phosphates such as Ephos phosphate are clearly indicated.

A number of trials extending over several years have been made on an estate scale with manurial systems for tea, and that which has met with the greatest success and which is being generally adopted is to apply at the time of pruning a mixture of 3 cwt. slaked lime, 1 cwt. basic slag, and 50 lb. of sulphate of potash, followed some six months later by a general mixture containing about 7 per cent. nitrogen, 5 per cent. phosphoric acid, and 5 per cent. potash, the phosphoric acid in this mixture being supplied in the form of fish guano and bonemeal.

An examination of the soil analyses which have been made in my laboratory during the past eight years reveals the fact that in nearly all cases our soils are deficient in available phosphoric acid as estimated by Dyer's citric acid test. This is shown by the following figures :—

Phosphoric acid.

—	Total			Available		
	Minimum	Maximum	Average	Minimum	Maximum	Average
Coffee soils (32) .	0·01	0·21	0·095	0·003	0·083	0·013
Tea soils (21) .	0·02	0·27	0·11	0·002	0·015	0·006
Rubber soils (10) .	0·027	0·17	0·08	0·0007	0·006	0·003

All these soils are markedly deficient in calcium carbonate content so that the presence of lime interferes but little with the determination of the citric-acid-soluble phosphoric acid as determined by Dyer's method. As a rule there is also a comparatively high content of oxides of iron and aluminium, and this in conjunction with the low lime content renders the total phosphoric acid slowly available. Consequently it is found that a combination of liming and the application of soluble phosphatic fertilizers is as a rule beneficial and better results are obtained by the use of this combination than of lime alone.

The figures for the soils quoted above are as follows :—

—	Calcium oxide			Oxides of iron and aluminium		
	Minimum	Maximum	Average	Minimum	Maximum	Average
Coffee soils (32) .	0·21	0·83	0·37	9·36	41·75	16·60
Tea soils (21) . .	0·10	0 ·56	0·21	13·97	30·06	23·43
Rubber soils (10) .	0·11	0·95	0·38	11·00	32·29	22·92

In view of the fact that the cost of transport to estates in South India is almost invariably high, the relative value of bonemeal, which gives the cheapest unit value of phosphoric acid, as compared with more soluble phosphates, needs study.

(10)

(N. Kunjan Pillai, M.A., B.Sc., Ph.D., *Director of Agriculture and Fisheries, Travancore.*)

On the basis of chemical composition the soils of Travancore can be divided into three classes :—

1. Soils of low-lying wet lands, mostly cropped only once a year, which receive an annual deposit of silt washed down by rivers from hills and forests. These soils contain on an average the following plant foods :—

	Per cent.
Nitrogen	0·17
Potash	0·28
Phosphoric acid	0·05

2. Soils of double crop wet lands cropped twice a year on which very little silt is deposited, containing :—

	Per cent.
Nitrogen	0·06
Potash	0·30
Phosphoric acid	0·05

3. Sandy soils found along the coast containing :—

	Per cent.
Nitrogen	0·01
Potash	0·02
Phosphoric acid	0·01

All the three types of soils are comparatively poor in phosphoric acid which varies from 0·01 to 0·05 per cent. The first two types are fairly rich in potash which is about 0·3 per cent. The potash content of the third type and the nitrogen contents of the second and third types are rather poor. As regards phosphoric acid there is practically no soil in Travancore which can be considered rich. Chemical analysis is not always a safe test to determine the fertility of a soil ; but in regard to the estimation of the requirements of Travancore soils in phosphoric acid the results of chemical analysis agree more or less with the results of manurial experiments conducted on the field. The application of phosphatic manures on wet lands as well as on dry lands has been found to increase considerably the yield of crops, chiefly paddy and coconut. Soils deficient in humus and nitrogen must naturally receive a good dose of organic manures, such as farmyard manure, green leaf, etc., in addition to phosphatic manures to produce adequate returns. In any case, there is no doubt whatsoever that all kinds of soils in Travancore respond readily to the application of phosphatic manures.

A large quantity of fish refuse is available in Travancore. It contains on an average 4 per cent. of phosphoric acid and 5 per cent. of nitrogen. The whole of this manure used to be exported to foreign countries till a few years ago. Now, however, through the efforts of the Agricultural Department a good portion of it is being used up here. Bone dust contains about 22 per cent. of phosphoric acid and 3·5 per cent. of nitrogen. The Department now imports several tons of this manure and sells it to the cultivators. Both fish refuse and bone dust are used largely on double crop wet lands and on coconut gardens, the soils of both of which are deficient in phosphoric acid and nitrogen. Superphosphate which is a simple and easily soluble phosphatic manure is also being imported by the Department to a limited extent and sold to cultivators for application on single crop

wet lands which are fairly rich in nitrogen, but deficient in phosphoric acid. When applied as top-dressing after the paddy seedlings are transplanted it is found to be very efficacious. The use of this manure and, to some extent, of bone dust is restricted by their comparatively high prices. Ordinary superphosphate containing about 20 per cent. of phosphoric acid, when imported into Travancore, costs about Rs. 120 per ton, and bone dust containing 3½ per cent. of nitrogen and 22 per cent. of phosphoric acid about Rs. 90 per ton, while fish refuse containing 5 per cent. of nitrogen and 4 per cent. of phosphoric acid can be purchased locally at about Rs. 45 per ton.

Taking the unit value of soluble phosphoric acid as Rs. 5, of insoluble phosphoric acid as R. 1, and of nitrogen in bone dust and fish refuse as Rs. 11, the manures in question may be theoretically valued as follows :—

	Per ton Rs.
Ordinary superphosphate	100
Bone dust	60
Fish refuse	59

Thus, comparatively speaking, superphosphate and bone dust are both more costly than the locally available fish refuse. If the prices can be brought down by the manufacture of these manures on a large scale in India, the demand for them in Travancore, I can safely assure, is bound to increase. In spite of the high prices the demand is increasing though slowly, and the increase will certainly be more rapid if the manures are made cheaper.

(11)

(T. Couper, M.A., I.C.S., *Director of Agriculture, Burma.*)

Analysis of twenty-four samples of soil from Lower Burma which are believed to be typical of large paddy-growing areas has been carried out in the laboratory at Mandalay. Several Upper Burma soils also have been analysed. A preliminary note (Bulletin No. 13) has been published and another is under preparation. The total phosphoric acid in these soils has been found to vary as follows :—

	Per cent.
Upper Burma—	
Soils	0·13—0·02
Lower Burma—	
Stiff clay	0·11—0·03
Clay loam	0·05—0·02
Sandy loam	0·09—0·02

In the sandy soils the phosphoric acid has been found much more readily available for the growing paddy plant than in the clay. Mr. Warth writes as follows :—

"1. Chemical analysis and pot cultures have shown that Hmawbi and many other Lower Burma soils lack a sufficient supply of P_2O_5. In this respect many samples are much poorer than Hmawbi.

"2. In pot cultures the crops from such soils are found to be strikingly deficient in P_2O_5.

"3. At Hmawbi it was observed one year that phosphoric acid gave a notable increase in the crop. The Deputy Director of the Southern Circle, who was closely observing this and the control crop, informed me that the crop to which phosphate had been supplied seemed fairly immune whilst the unmanured crop was badly attacked by insects and the difference in yield might be attributed to the effect of pests alone. Next year on fresh but similar land phosphate gave no benefit. These results lead one to conclude that at Hmawbi phosphate is necessary only to ward off pests during unfavourable years. They bring out also very strikingly the significance of the low P_2O_5 content of the crop when grown in this soil.

"4. These last observations combined with (*a*) analytical results showing extreme poverty of many soils in P_2O_5 and the concurrent abnormally low P_2O_5 content of the crop and considered together with (*b*) the fact that there are many areas in which when conditions are at all unfavourable the crop is extraordinarily reduced or fails entirely, indicate that P_2O_5 will probably prove to be an essential manure in the great rice-growing areas of Burma. Whether the paddy crop can afford to pay for superphosphate or must be ameliorated more slowly by crushed bone is a question of crop economics to which the agricultural experts must find a reply."

Prolonged experiments with phosphatic manures have been made on the departmental farms. At Hmawbi in the past four years the use of bonemeal and superphosphate in quantities to supply 20 lb. phosphoric acid an acre to the paddy crop has brought about an average increase in out-turn of 28 per cent. and 40 per cent. respectively. In Upper Burma similar results have been obtained. But it has not been established so far that these manures can be applied at a profit. Mr. McKerral writes :—

"In the case of bonemeal, dissolved bones, and superphosphate it was found that profits of Rs. 5 and Rs. 6 per acre could be got from their application. This profit, however, is liable to fluctuation and last year bonemeal which cost Rs. 80 per ton in Calcutta barely paid for itself. There is no doubt about the value of bonemeal for exhausted paddy land

and all that is required is to be able to purchase it cheaply enough. Its use is at present unknown among paddy cultivators, although the amount of bones produced in the country must be very large and the pre-war export was considerable. This manure ought to be available in this country and if obtained at from Rs. 40 to Rs. 50 per ton would in most cases be a valuable manure. My recommendations are as follows :—

"(*a*) An attempt should be made to retain in the country bones and other products of an animal nature.

"(*b*) Government should either promote itself or subsidize a company to begin an internal trade in the above materials. Prior to the war bonemeal was made in Rangoon by a German firm which, it is well known, made enormous profits in this business. A Rangoon firm has this year erected a bone mill at Thazi and is prepared to sell at Rs. 65 f. o. r. The product consists of half-inch bones and this kind of bonemeal has not yet been tested. Besides it is almost certain that Rs. 65 will prove to be much too high a price for its use in paddy cultivation. The German firm bought bones from the Rangoon Municipality at Rs. 20 per ton and it should not cost more than Rs. 10 to convert a ton of bones into bonemeal. Allowing another Rs. 10 for profit it should be quite possible to sell bonemeal to cultivators at Rs. 40 to Rs. 45 per ton and at this price good profits could be got from its application. The amount of bones exported must be a mere fraction of the amount available and every effort should be made to organize collection and extend the industry.

"(*c*) A survey of the possibilities of Burma with respect to supplies of fish manure should be made. This material which is got from prawn refuse, is made mainly in the Mergui District and is almost all exported to the Straits and Hongkong. In America there is a very large trade in fish-oil and fish-cake, and it is possible that a similar industry might be started in Burma, where the coast line is large. This would require scrutiny by a fisheries expert. An industry of this kind has recently been started in Madras."

The position then, despite the temporary cessation in the export of bones, seems to be that such phosphatic manures as are produced in the province are not available to the local cultivator, as paddy is not of sufficient value to enable him to compete for these manures against

growers of more valuable crops in other countries, while superphosphate and basic slag cannot be manufactured in the absence of the necessary mineral deposits. It would seem that in the cheapening and increased use of these manufactured manures in other countries is the main hope of locally produced phosphatic manures being set free for local use.

Export (in tons) of manures from Burma.

Bones—

	1912-13	1913-14	1914-15	1915-16	1916-17
Great Britain . . .	384	..	..	1,080	..
Ceylon	100	..	100	100	..
Germany	683	300	699	..	..
Belgium	702	784	2	..	..
Japan	75	560	100	..	..
Total (including countries not separately enumerated).	1,966	1,681	913	1,235	76

Fish manures and guano—

	1912-13	1913-14	1914-15	1915-16	1916-17
Straits Settlements . .	3,082	4,997	4,297	2,452	3,275
Hongkong	31	32	55	24	114
Total . . .	3,113	5,029	4,352	2,476	3,389

(12)

(H. A. F. LINDSAY, I.C.S., *Director-General of Commercial Intelligence, Calcutta.*)

I have approached this subject solely from the commercial point of view. That is to say, what are the sources of supply, and at what prices and in what quantities are superphosphates available ?

I. *Pre-war conditions.* For the year ending 31st March, 1914, the imports of superphosphates into British India totalled 582 tons, of which

Madras and Calcutta took 315 and 263 tons respectively, and between them practically all the trade. The average landed values for the year varied from Rs. 70 at Madras to Rs. 88 at Calcutta.* The *Chemical Trade Journal* quotes £2-17-6 as the market price of mineral superphosphates (18 %) in the United Kingdom for March 1914.

II. *War conditions.* I have no statistics of imports during the war, but understand that Japan is now the principal source of supply. Her exports to all destinations increased from a total value of about £57,000 in 1914 to £258,000 in 1915 and £412,750 in 1916. The Calcutta landed price is now, I understand, Rs. 100—120 per ton.

III. *Prospects of manufacture in India.* In this industry India is handicapped at every turn. The two main factors required are :—

(*a*) Cheap and plentiful supplies of sulphuric acid.

(*b*) Cheap and plentiful supplies of phosphatic material.

I have consulted several firms interested in the manufacture either of sulphuric acid or of superphosphates or both and have obtained the following information :—

(*a*) With regard to sulphuric acid, there are, so far as we know at present, no crude sulphur deposits of commercial value in India. Indian pyrites (an alternative base) are not rich in sulphur. The usual trade quality of English and Spanish pyrites contains 48 to 49 % of sulphur. The Indian deposits vary from 17 % (not at present commercially workable) to 30 % (barely workable). Practically all the sulphuric acid hitherto manufactured in India has been made from Sicilian sulphur, costing approximately Rs. 90 per ton landed in India before the war, or Japanese, costing slightly less. The present price of sulphur in India is Rs. 200 to Rs. 240 per ton. There is therefore no prospect at present of cheap supplies of sulphuric acid. It might be manufactured from the 30 % pyrites locally available, but so far as I can gather this quality is only commercially workable as a result of war conditions, and any scheme depending on the use of 30 % pyrites would not be able to face a return to ordinary trade conditions after the war. Firms known to be manufacturing sulphuric acid at present are :—

1. The Bengal Chemical and Pharmaceutical Works, Ltd., 91, Upper Circular Road, Calcutta.

* The high price is probably due to the imported superphosphate partly consisting of double-strength (40 per cent.) superphosphate. This is especially the case with the Calcutta import [W. A. D.]

2. Messrs. D. Waldie and Company, Konnagar, Calcutta.
3. The Tata Iron and Steel Company, Ltd., Sakchi.
4. The Eastern Chemical Company, Ltd., Messrs. Shaw Wallace and Company, P. O. Box 203, Bombay.
5. The East India Distilleries and Sugar Factories, Ltd., Madras.
6. The Burma Chemical Industries, Ltd., 38, Sule Pagoda Road, Rangoon.

(*b*) Superphosphates are manufactured, by sulphuric acid treatment, either from bonemeal or from mineral phosphates. The price of the former is about Rs. 70 per ton. The commercial value of mineral phosphates in India is still a matter of enquiry. If competition with imported superphosphates is to be successful in peace time they should be marketed locally at Rs. 20 to Rs. 25 per ton. Apatite occurs in Hazaribagh, apatite rock deposits in Dalbhum, and triplite in the Gaya District. Phosphatic nodules also occur in Trichinopoly. It is understood that the Dalbhum and Trichinopoly deposits are being worked at present, but with what success is not known. Firms manufacturing superphosphates are :—

The Great Indian Phosphate Co., Ltd., Messrs. Andrew Yule & Co., P. O. Box 150, Calcutta, in addition to the Eastern Chemical Company, Ltd., and the East India Distilleries and Sugar Factories, Ltd., and Messrs. Waldie, already mentioned. The Bengal Chemical and Pharmaceutical Works, Ltd., would be willing to take up the manufacture if there were reasonable prospects of a steady demand.

IV. If I might be allowed to make a suggestion, I think the following might be found a workable scheme :—

(1) To make a beginning with the indigo districts of Bihar where need for superphosphates and their commercial value as a fertilizer for the indigo crop are known.

(2) To lay the facts before the Bihar Planters' Association, drawing special attention to the value of superphosphates and the results anticipated, and asking for support.

(3) To ask Messrs. Shaw Wallace and Company and Messrs. Andrew Yule to tender for the supply of, say, * 500 tons superphosphates to be delivered at Muzaffarpur, as an experiment, for the next season.

* Or any other quantity arrived at in consultation with the Association.

(4) On receipt of tenders, to accept them in consultation with the Association if they are obviously likely to give a good return—distribution to factories and the recovery of the cost price *pro rata* from the recipients to be made through the Association.

(5) If the prices asked are not reasonable, they at any rate afford a basis for negotiation, and lower prices might be secured for a larger quantity ordered.

(6) Subsequently, for other crops, purchase and distribution might be effected either by the Agricultural Department or by the Co-operative Credit organization of Bihar and Orissa.

(7) It is not unlikely that a reference to the railways concerned would ensure a reduction of freight at any rate on the experimental consignments.

(13)

Copy of letter No. 5347, dated 7th September, 1917, from the Director-General of Commercial Intelligence, Calcutta, to the Agricultural Adviser to the Government of India, Simla.

With reference to your letter No. C.-211 of the 12th July last, I have the honour to inform you that I have taken up an enquiry into the possibility of the manufacture of superphosphates on a large scale in India. In the course of the enquiry I addressed a number of firms interested in the manufacture both of superphosphates and of sulphuric acid and propose if convenient to discuss the replies with you at Simla this month.

2. As you are aware I am particularly interested in the commercial aspects of the proposal and have studied it chiefly from this point of view. There are three outstanding points on which I will be glad of your views before proceeding further. I may add that they were suggested to me in personal discussion with Messrs. Shaw Wallace and Company who are interested in the manufacture of superphosphates.

3. In the first place there is the question of price. Imported superphosphates fetched Rs. 60 to Rs. 65 per ton in Calcutta before the war. At this price I understand they were chiefly taken by tea gardens and large agricultural concerns and scarcely reached the small cultivator if at all. My first question therefore is roughly at what price superphosphates would have to be landed, say, at a station on the Bengal and North-Western Railway in order to make their purchase profitable to cultivators within easy reach of the station. Would this landed price have to be Rs. 60 or Rs. 50 per ton or less ? As already stated it did

not apparently attract the cultivator at Rs. 60 *c. i. f.* Calcutta, although this absence of interest may have been due either to ignorance of the need for artificial fertilizers or to the fact that the suppliers have hitherto made little or no attempt to get into touch with the cultivators. If we could ascertain what price the ryot ought to be able to pay for superphosphates we should have definite ideal at which to aim.

4. In this connection and secondly, I may say at once that with raw bones at Rs. 30 per ton up-country and mineral phosphates not yet locally available in sufficient quantities or of satisfactory quality, sulphuric acid would have to be extremely cheap if local superphosphates were to undersell those imported. I am given to understand that bone superphosphates are superior to imported mineral superphosphates, in that they contain nitrogen in addition to phosphoric acid, and can be prepared in varying proportions of nitrogen and phosphoric acid to meet local requirements. I would like to know whether you endorse this view and whether you consider that local enterprise should seek as much as possible to specialize on bone in preference to mineral superphosphates.

5. In the third place I am uncertain what machinery is contemplated to bring the producers in touch with the cultivators ; possibly the Co-operative Credit authorities or the Agricultural Department could assist. In any case it is certain that the organization for distribution would have to be on an extensive scale, and not merely the production.

(14)

(*Note on Superphosphate Costs and Returns in Bihar, by W. A. Davis.*)

If superphosphate could be produced in India at the same price as imported superphosphate before the war, *viz.*, Rs. 60 to 65 per ton, there should be a very good market for it in Bihar and probably in other provinces. I have, in my article in the *Agricultural Journal of India*, Special Indian Science Congress Number, 1917, drawn attention to the extraordinary impoverishment of most of the soils of Bihar in this constituent, and pointed out how, wherever superphosphate has been used on the large scale, it has given surprising increases of crops. I will here add data of the actual increases of crop required to pay the cost of manuring with super and show that the probable increases obtained are likely far to exceed these so that manuring would be very profitable.

Indigo. Assuming superphosphate to be applied at the rate of 2 cwt. to the acre, if the manure cost Rs. 60 per ton, cost per acre =Rs. 6.

If the ryot be paid As. 4 per maund which is the current rate for plant an *increased yield of 24 maunds of plant* would just pay the cost of manuring.

There is little doubt that the increased yield would be far greater than this. At present the yield of plant per acre, with Java plant and Sumatrana plant, shows extraordinarily great variation, *viz.*, from about 40 maunds of green plant to as much as 120 maunds.

The impoverishment of the low-yielding soils as shown by a very large number of analyses is in practically all cases due to nearly complete depletion of available phosphate. There is therefore good reason to think that the increase of yield on most estates would be far more than the 24 maunds required to pay for the cost of the manure.

As regards the indigo planter on his own *zerat* lands, with indigo at pre-war prices, say, Rs. 170 per maund, and yield of indigo of, say, 9 seers per 100 maunds Sumatrana plant (which is a low estimate that should be capable of considerable increase by improvements in manufacture), it can be calculated that an increase of 16 maunds of plant would cover the cost of manuring with 2 cwt. of super to the acre, super being taken at Rs. 60 per ton.

At the present time with indigo at Rs. 450 per maund and super in Bihar at Rs. 125 per ton (of which freight from Calcutta represents Rs. 23) the cost of manuring with super 2 cwt. per acre=Rs. 12½. An increased crop of only 12 maunds of green Sumatrana plant per acre would cover the cost of manuring even if the yield of indigo were as low as 9 seers per 100 maunds of plant. In the case of the Java plant yielding, say, 18 seers of indigo per 100 maunds, an increase of only 6 maunds of plant per acre would cover the cost of manure.

At the present time the *zerat* lands largely fail to yield *khoonties* at all, mainly because of their impoverished conditions as regards phosphate. By proper manuring with superphosphate these *khoonties* can be greatly increased, and made to yield crops nearly equal to the first cutting. The falling off in *khoonties* this year has been very marked as compared with last year, owing to drastic stripping of the small reserves of phosphates left in the soil.[1]

Oats. Mr. Mackenzie of Sapaya informs me that by manuring his lands with superphosphate *plus* green manure he has increased his crops of oats in the three last years as follows :—

	Mds. of 82 lb.
1st year average out-turn per acre	12·00
2nd year „ „ „	19·50
3rd year „ „ „	23·00

[1] See *Indigo Publication* No. 1. "A study of the indigo soils of Bihar."

If oats be taken at the current rate of Rs. 2-8-0 per maund and manuring be at the rate of 2 cwt. per acre, an increase of about $2\frac{1}{2}$ maunds per acre would pay the cost of manuring (super at Rs. 60 per ton). On most estates I have little doubt the increase would be far greater than this—in the above case the increase by manuring was 11 maunds per acre. The Pusa Experimental Farm results for 1915-1916 show that with oats, superphosphate alone *doubles* the crop. The return on unmanured land was only 665 lb. per acre ($8\frac{1}{2}$ mds.), whilst with super 1,162 lb. per acre ($14\frac{1}{2}$ maunds) were obtained. That is an increase of 6 maunds to the acre. With combined green-manuring and superphosphate the increase at Pusa was from 665 lb. ($8\frac{1}{2}$ maunds) to 1,840 lb. (23 maunds) per acre, that is an increase of $14\frac{1}{2}$ maunds per acre.

Wheat and Barley. With *wheat* at the current price of Rs. 3-14-0 to Rs. 4-12-0 per maund according to quality, the increase of crop required to cover the cost of manure (2 cwt. super per acre) would be considerably less than 2 maunds per acre. In actual practice where super has been applied the increase has been far greater. Thus at Dooriah an increase of 4 to 7 maunds of wheat per acre was obtained with only 2 maunds of super per acre.

With barley at Rs. 2-6-0 to Rs. 2-10-0 per maund an increased yield of the same order as with oats would be required to cover cost, *viz.*, $2\frac{1}{2}$ maunds. At Dooriah increases of 4 maunds were obtained in one field, whilst in another, clearly a badly impoverished field, the increase was as great as 16 maunds per acre.

Maize. With maize at Rs. 1-14-0 to Rs. 2-2-0 per maund an increase of about 3 maunds produce per acre would pay manuring with 2 cwt. superphosphate per acre at Rs. 60 per ton. The actual increase of yield in Bihar would probably far exceed this. Last year at Pusa in one field super alone increased the crop from 806 lb. per acre (10 maunds) to 1,201 lb. (15 maunds). In another set the increase was from 474 lb. (6 maunds) to 1,151 lb. ($14\frac{1}{2}$ maunds), that is an increase of $8\frac{1}{2}$ maunds per acre. By combined green-manuring plus superphosphate the yield in the latter field was increased from 474 lb. (6 maunds) to 1,552 lb. ($19\frac{1}{2}$ maunds), or an increase of $13\frac{1}{2}$ maunds per acre.

More valuable crops such as Mustard and Tobacco. With more valuable crops such as mustard (at Rs. 5-2-0 to Rs. 6-4-0 per maund) an increase of only one maund per acre would pay the cost of manuring with 2 cwt. super per acre.

Actually the largest increases have been found with this crop in Bihar. The field trials at Dalsing Serai by Bernard Coventry showed with mustard an increase of 800 per cent. in 1899, 300 per cent. in 1900, and 250 per cent. in 1901. The use of superphosphate in 1899 increased the

crop from 6 maunds to 27 maunds per acre, that is a gain of 21 maunds ; whilst in 1901, 2 cwt. super per acre increased the crops from 13 maunds on the unmanured portions to 25 maunds on the phosphate-treated fields, an increase of 12 maunds. Manuring with 5 cwt. of super per acre increased the crops to 28 maunds, that is an increase of 15 maunds per acre. Experiments made this year (1917) by Francis Coventry at Dalsing Serai confirmed the extraordinary increase in mustard by manuring with superphosphate.

With this crop Coventry calculated that the actual net profit after allowing for the cost of manure was greatest on the *most heavily manured* portion. Thus with 5 cwt. of super the net profit was Rs. 110 per acre, whereas on the unmanured land it was only Rs. 51 per acre.

With *tobacco* there are few reliable data at hand for Bihar, but there is little doubt from experiments recently made at Pusa that superphosphate would considerably increase both yield and quality. In the experiments at Dalsing Serai in 1901, the net profit was greatest (Rs.74 per acre) on the plot treated with 2 cwt. of super and $\frac{1}{2}$ ton oil-cake (no experiments with superphosphate alone are recorded), whereas with no manure the profit was only Rs. 51.

Thus if superphosphate could be supplied at the pre-war price of Rs. 60 per ton, there is little doubt that in Bihar at any rate the increased returns would far more pay than the cost of manuring at the rate of 2 cwt. per acre and in most cases give very substantial increase of crop. That superphosphate has not been more widely used in the past in Bihar is, I think, largely due to ignorance of the vital necessity of such manuring. Its use will, I think, increase greatly as its value is more generally recognized.

It is probable too that in many other provinces its use would prove beneficial. Thus, for example, in the current report of the Madras Department of Agriculture (1916-1917) it is stated that " the use of superphosphate as a manure for paddy is becoming popular in the south ", and that it gives a return of at least 100 per cent. on the money invested on it.

Use of superphosphate in preference to raw bones. In Bihar where the soil contains an abnormally high proportion of calcium carbonate (30-40 per cent.) crushed or powdered bonemeal does not as a rule give any useful result ; the high proportion of lime in the soil, by neutralizing the acids, particularly carbonic acid, produced by bacterial action, prevents the liberation of water-soluble phosphoric acid. Consequently for such districts bones as such are frequently useless as manure, and they must be treated with sulphuric acid before they have a fertilizing

value. It is possible that in conjunction with green manure they would be more readily assimilated.

It is quite possible, however, that for *paddy*, which is grown under water, the use of superphosphate might prove less economical than crushed bones, and that the latter would give useful results as the bacterial conditions of the paddy crop are exceptional. But I have no reliable information as to the relative value of crushed bones and superphosphate in the case of this crop.

Cost of sulphuric acid. A superphosphate factory would necessarily have to run its own sulphuric acid plant and any excess of acid it produced could be put on the market. The price of sulphuric acid in India is prohibitive of its use in many industries. If it could be produced at a low price such as ruled in England before the war (say £2 per ton) it would be a great advantage and make several industries possible which at the present cannot be even considered on account of the excessive cost of sulphuric acid—the starting point of so many industrial processes.

The Improvement of the Indigenous Methods of *Gur* and Sugar making in the United Provinces.*

THE improvement of the indigenous methods of *gur* and sugar making in the United Provinces has been under consideration for some years. The rapid increase in the imports of sugar before the war, caused some anxiety to those in authority, and steps were taken with the view of improving the sugar industry in India.

In the United Provinces a large quantity of sugarcane is grown; *gur* and sugar are made, some of which is sent to the Punjab and other parts of India. Consequently investigations were commenced in the Bareilly District. A small experimental factory was erected in 1914-15. The site chosen was the Government farm at Nawabganj between Bareilly and Pilibhit.

On this farm experiments are made in sugarcane growing and all the varieties grown have been analysed and tested as to milling properties, at the experimental factory, to find out the best varieties for local adoption.

So much depends on the nature of the soil, the manures used, the season, and the methods of cultivation, that nothing positive has as yet been found out as to which of the varieties are the best. For a sugar factory varieties ripening early and late are essential. Experiments point out that if *Saretha*, a tall thin cane, is sown a little earlier, it will perhaps be ready for crushing about the third week of November, though it may not obtain its full maturity. *Chin* also has a tendency to ripen early. *J. 33*, which is perhaps the best variety yet grown on this farm, would ripen in February, and *Dhour*, *Kagzi*, etc., in March. *Uba* and *Agoul* are two very good tall thick varieties, but they contain so much wax and gummy matter that it makes them very difficult to handle. A good deal of trouble was experienced with these varieties this year, the filters choking in half the usual time. The settling in clarifiers also was extraordinarily slow.

In 1915-16 it was intended to test the efficiency of the newly erected plant, but the late arrival of some of the machinery and the difficulty of obtaining a sufficient supply of cane were factors that spoiled the chance of a full season's work. However, the factory was worked whenever

* A note submitted to the Tenth Meeting of the Board of Agriculture, held at Poona in December, 1917.

cane could be obtained, and altogether it was worked for 54 days, sometimes for a few hours per day and at other times for 24 hours. During these spells of working, useful information was gained. The crushing and extracting capacity of the cane mill when working with six rollers, nine rollers, and eleven rollers, was tested. Numerous experiments were made in the clarification of juice. No doubt best and most upto-date scientific clarification methods are in vogue in big modern sugar factories, but the difficulty lay in the fact that the writers wanted to make the method as simple as possible. Simple lime clarification method was quite good, but, with the class of canes available, it did not produce white sugar. Sulphitation was therefore adopted. Sulphurous acid can only exercise bleaching effect in acid medium. In fact any acid will give light coloured juices, but then, in the first place, the inversion, though nominal up to the filters, was very high in the film evaporator with acid juices, though the product was quite white, and, in the second place, if calcium bisulphite was formed it went in solution and was reprecipitated in the evaporator. On the other hand juices slightly pink to phenol-phthalein gave better results as the danger of inversion was reduced and the voluminous precipitate of insoluble calcium sulphite carried down with it other coagulated impurities. This method was adopted in the latter part of the season this year, but it could not be fully tested. Next time it is expected to be given a full trial. To have the full advantage of sulphitation, the modern scientific world uses double sulphitation method, *i.e.*, they sulphite the syrup as it leaves the triples. This, though surely causing some inversion, cannot do any harm in vacuum pans where the temperature remains low, but here, where the temperature gets to about 98° or 99°, the danger of inversion is very great, therefore, it is yet to be seen what grade of product is obtainable without a second sulphitation and without leaving the juices slightly acid as till now. Filtration and concentration of the juice was tried in several ways, and the experiments led up to certain modifications of the plant and a few additional parts are being made at the Canal Foundry, Roorkee, and delivery has been promised by the middle of August 1917. If delivered in August they will be erected in readiness for the season 1917-18, when it is hoped that the factory will receive sufficient sugarcane for a full season's work. If the present monsoons are favourable a sufficient supply of sugarcane is assured.

In the season 1916-17 the sugarcane crop in the Bareilly and Pilibhit districts was a complete failure. Owing to the excessive rain, rust and smut destroyed much cane, and only a comparatively small quantity of a very inferior sugarcane was available.

The Agricultural Adviser to the Government of India, accompanied by the Director of Land Records and Agriculture, United Provinces, visited the factory on the 8th December, 1916, and was shown the hopeless condition of the crop.

Later on in the season an interesting experiment was carried on; a bundle of cane containing about 200 to 400 sticks was weighed each day successively for a week with the result that the average stick of cane weighed only 2·21 *chhataks* or about $4\frac{1}{2}$ oz. as compared with $1\frac{1}{2}$lb., the average weight of cane in the Peshawar District, where the senior author was invited by the Government of North-West Frontier Province to consider the possibilities of sugar manufacture in that province. Though the writers have no figures to show the weight of an average cane in countries like Java and Mauritius, yet they are sure that it is much more than at Peshawar.

Sugar and *gur* were made, analyses were made daily and further experiments were made in the factory, and the results recorded. (*See* the table of analyses in the Appendix.*) But with such a small quantity of inferior sugarcane the factory could not be tested as to efficiency or as to whether or not it could be made a commercial success.

After briefly describing the indigenous methods of *gur* and sugar making in these provinces, a description of the new experimental factory at Bareilly will be given.

Indigenous Methods.

A very large proportion of the sugarcane grown in these provinces is crushed by the small country-made mills, which have two or three rollers 8″ in diameter and are wonderfully cheap. They are, however, of a type which has been discarded by the modern scientific world on account of wastefulness; the rollers being arranged vertically, some of the expressed juice falling down by gravitation is picked up and carried away by the lower crushed canes passing from the mill and so is lost.

The mills are designed to be rotated by a pair of bullocks, such as are found locally, and give an extraction of about 50 per cent. when crushing good cane, which compared with the modern MULTIPLE MILL shows a loss of 25 per cent. at least.

From a broad economic point of view, the low extraction given by these mills is a national calamity, but from the cultivators' point of view, it is "Hobson's choice." He would like very much to get more

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* *See* page 14.

juice, but he cannot afford to buy or hire a better mill and stronger bullocks, which would be necessary to get higher extraction, whilst, on the other hand, the *khandsari* (the native sugar manufacturer), to whom he sells the juice, does not like too much sucrose being taken out of the cane because it reduces the calorific value of the crushed cane as fuel, which he uses for boiling and concentrating the juice.

The Nahan Foundry THREE ROLLER MILL, which is an improvement on the type most commonly in use, has hardly found any favour with the ordinary cultivators, because it is more costly than the ordinary mill and the bullocks required to drive it need to be more powerful and consequently more costly than they can afford to keep.

Gur making indigenous method.

In *gur* making the juice after being expressed by the country mill is put into a shallow iron pan, about three feet six inches in diameter, under which is a furnace (a hole in the ground) ; the fuel used is dried leaves and the crushed cane dried in the sun. The juice is boiled and concentrated to about 44° " Beaume ". specific gravity 1·438. The attendant, when the mass in the pan becomes very thick, takes out a little, dips it into cold water, and rolls it into a small ball, and by this means he can tell when it is ready. When ready it is ladled on to flat, circular, flanged plates, about 3 feet in diameter, made of clay and straw, on which a little quantity of *reh* or alkali earth has been sprinkled. The object of this *reh* is to improve the colour as well as to keep the stuff from adhering to the plates. A layer of the *gur* in a semi-liquid form, about one inch thick, is allowed to cool down to a certain degree which the coolies know by touch, then two coolies vigorously stir it up with wooden tools shod with iron, and when it becomes pliable like baker's dough it is shaped into cakes or balls or lumps to suit the market in which it is to be sold. Some *gur*-makers pass the juice through a cotton cloth to take out bits of cane and other impurities ; others do not. In the Bareilly District a recovery of eight to nine maunds of *gur* per one hundred maunds of cane is made. This *gur* is inferior to the Meerut *gur* in colour and purity, which is probably due to the inferior cane and the dark coloured juice from it. It is said that in some districts the cane yields 10 per cent. of *gur* or even more.

Sugar making indigenous methods.

The country mills are usually hired by co-operant cultivators and are fixed up adjacent to the *bel**, which is owned by the *khandsari* who

* " Bel " = Indigenous factory.

pays money in advance to the cultivator to insure the supply of juice during the cane crop, for which the *khandsari* pays his own price to the cultivators who are often in debt to him. It is to be noted that the *khandsari* buys the juice ; he does not buy the cane, so that if there is a bad season, or a succession of bad seasons, and the crop is poor, the cultivator suffers and not the *khandsari*. When the climatic conditions cause the canes to be stunted and the fibre content is high, it often happens that the juice is rich, so that the *khandsari*, buying the juice by measure, gains and the cultivator loses.

The *bel* usually contains five iron pans of the cheapest possible kind, which are built up on a furnace made of mud, in a mud house roofed with grass. One cannot conceive anything that would be less costly. The pans vary in size ; the juice is put into the largest pan and boiled and evaporated until it is reduced in volume by 50 per cent., it is then ladled into the next pan and further evaporated and concentrated and so on until it reaches the fifth pan where it is highly concentrated and made ready for crystallizing out. It is then placed in large earthenware vessels about two feet high and one and a half feet in diameter. After partial crystallization the stopper is taken from a small hole in the bottom of the vessel and the molasses is allowed to drain off. A river grass called *sewar* (*Vallisneria spiralis*) is placed on the top of the sugar to a thickness of two or three inches, which has the effect of removing the molasses on account of moisture and its power to retain heat, bleaching the sugar to a depth of half an inch or more.

The *sewar* is changed daily until the whole contents of the vessel have been treated. The sugar taken off each day is taken to the *pata*, a level floor surrounded by a low wall. The sugar is here dried in the sun and crushed by coolies walking on it and twisting their feet as they walk. This is called *swadeshi* sugar for which orthodox Indians will pay higher price than can be obtained for the high class modern factory sugar.

There is another indigenous process in which the *rab** is put into gunny bags, placed one upon another six or seven high ; a cooly stands upon the top bag supported by a pole and sways backwards and forwards, and by this means most of the molasses is separated from the sugar. The bags are then emptied into wooden bins and the sugar is treated with *sewar* grass as mentioned before, then sun-dried, and ground by coolies walking on it with the twisting movement of feet. By these indigenous processes the recovery of sugar from 100

* "Rab" = Mixed crystallized sugar and molasses.

maunds of cane is 3 maunds as against 10 maunds by the modern process in tropical countries.

There is another process in which after concentration in the five pans the massecuite *rab* is put into *kalsis*, earthenware vessels holding about forty pounds, and when it has crystallized out it is centrifuged ; the molasses then taken off is again boiled and concentrated and a second sugar is made and the molasses is again spun off in the centrifugal machine, and although it is still rich in sucrose it is sold for mixing with tobacco and cattle feeding. The produce by this process is about 4%.

Any improvement of a permanent character would probably cost a hundred times the amount or more than what is spent on the temporary mud-house and arrangement of pans. The cultivators have no money to spend, and the *khandsaris* who are rich do not desire any change.

Some of the more prosperous cultivators have adopted, and others are inclined to adopt, power-driven mills, and the kind of power most favoured seems to be the oil-engine.

It is an ideal scheme to have some kind of motive power, other than bullocks, on a farm, but if it were assumed that oil-engines could be worked successfully by the cultivators, and that they could be used for driving sugarcane crushing mills, the question arises as to whether their use could be made a commercial success. Would the general adoption of oil-engines in sugar production be likely to check or reduce the rapid increase in the importation of sugar recorded previous to the war ? The senior author ventures to say that it would not.

In a modern factory crushing, say, 1,000 tons of cane per day (which is a moderate quantity), little or no fuel is required other than megasse. In the case of the oil-engine-driven mill the cost of the oil would be a serious handicap.

The extraction of juice by the THREE ROLLER MILL, no matter how powerful, must be less than that obtained by a FOURTEEN ROLLER MILL or a TWENTY ROLLER MILL with maceration or imbibition such as are now used in modern factories ; and in any improved factory it is essential that a MULTIPLE MILL be used to ensure high extraction.

The climate of the United Provinces is not as favourable to the growth of sugarcane as is the climate of the tropical sugar-growing countries. In Bareilly District very cold weather, and sometimes frost, occurs in December and January just at the time when the cane is ripening ; growth is stopped and glucose keeps high as will be seen on reference to the Appendix. It has been found that the cane, especially the thicker and softer varieties, are not ripe until February,

so that the cane crushed previously is high in glucose, low in sucrose, and the density of the juice low, which is a considerable disadvantage when compared with countries where there is neither frost nor cold weather.

The following amazing figures which are quite reliable will serve to show the best and the worst sugar production that the writers know of :—

Sugarcane produced per acre.

	Maunds
Java	1,100
Bareilly District	250

Sugar produced per acre.

Java	110
Bareilly District (indigenous methods)	7½
	Tons
100 acres of cane in Java yield	404
100 acres of cane in Bareilly yield	27¾

In the Bareilly District it is impossible to get an out-turn equal to Java, but improved cultivation and modern factories would very much improve matters as the following figures will show.

On the Government Farm, Bareilly District, a sugarcane, *J. 33*, was produced at the rate of 600 maunds per acre, and at an adjacent sugar factory, Pilibhit, 7½ per cent. is the recovery of sugar from indigenous cane. This works out at 45 maunds of sugar per acre, which is a considerable improvement on 7½ maunds by the indigenous methods.

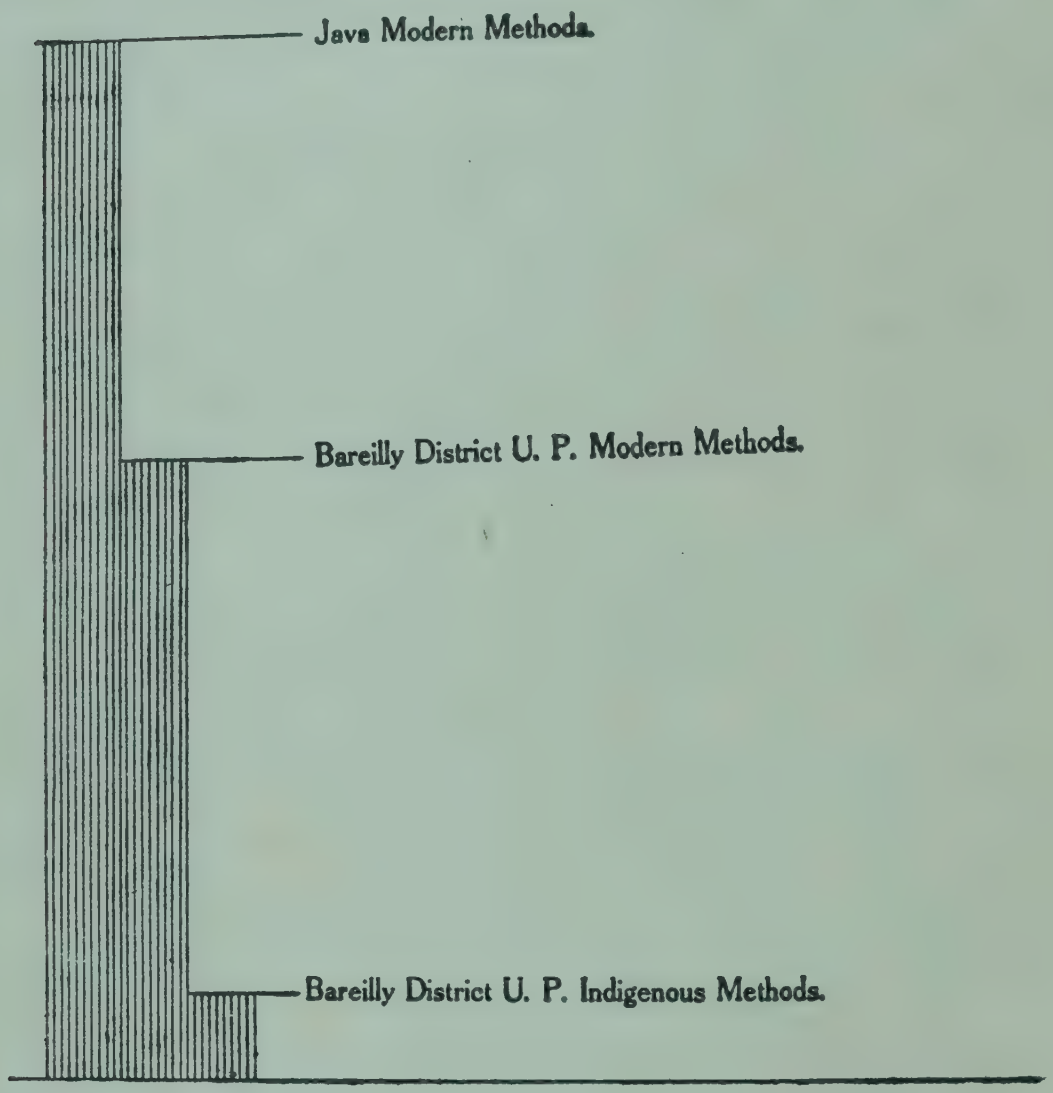
By means of intensive cultivation it is possible to produce on this farm 800 maunds of cane per acre, and it is likely that with the better cane the recovery of sugar at the factory (Pilibhit) would be brought up to 8 per cent. This would give a recovery of sugar per acre of 64 maunds.

Sugar produced per acre.

	Maunds
Java (modern methods)	110
Bareilly District (modern methods)	64
Bareilly District (indigenous methods)	7½

(*vide* Diagram below).

Diagram of Sugar Produced per acre.



Sugar imported into the United Provinces from Java has to bear considerable charges, which go far, no doubt, to level up the prices.

Import duty 10 per cent., shipping freight, railway freight, handling in Java at the docks and at Calcutta, warehousing, agents' fees, etc., amount to a considerable item, which must be debited against Java's production.

The writers have had no opportunity of obtaining reliable figures of the cost of production of sugar per acre in each case, which would have been very interesting for the purpose of comparison.

At least we see by the above comparative figures that the very best cultivation is necessary and factories of the highest efficiency are essential, if India is to compete in her own sugar markets.

Experimental Factory, Bareilly.

The factory (Plate I, fig. 1) was erected in 1914-15, and the plant was designed by the senior author with the view of improving the indigenous methods and, in his opinion, it is the smallest plant that could be worked on a commercial basis. Care has been taken to make the machinery and process as simple as possible, so that the superskilled management and highly technical supervision, so essential in large modern factories, would not be necessary.

In the initial stages the plant is being worked under expert technical control, with a view to find out whether a plant like this could be confidently placed before the public as the first step towards improvement of the methods of indigenous sugar manufacture, which small capitalists, such as zemindars or ordinary *khandsaris*, would be able to go in for. An attempt is being made to produce white sugar without the aid of a vacuum pan, and all its appurtenances which are so costly, requiring expensive highly trained men to control.

The experimental work was proceeded with during the seasons 1915-16 and 1916-17, but it was found to be impossible to obtain sufficient sugarcane to run the factory for a complete season, especially as the sugarcane crop in 1916-17 was a complete failure in the Bareilly District, only a small quantity of very inferior cane being available.

The local cultivators were found to be so much in debt to the *khandsaris*, who freely give advances to ensure a supply of juice during the season, that they could not sell their cane to the factory even when offered higher prices than the *khandsaris* gave.

The cane grown in the locality by the ordinary cultivators is of a very poor quality, as will be seen by a reference to the Appendix.

The most favoured varieties of cane are *Chin*, *Padaria*, and *Dhour*. The *Chin* is a cane with a hard rind and a fibre content of 17 per cent. to 19 per cent. *Dhour* and *Padaria* have a fibre content of about 15 per cent. The cultivators plant the hardest varieties of cane which will have the least chance of being damaged by wild pigs and other animals which abound in this district.

On the Government Farm, Bareilly District, softer varieties have been grown, but it has been necessary to use wire fencing to keep out

the pigs. This could not be done by ordinary cultivators owing to the high cost of the fencing.

Experiments at the Farm with new varieties of cane were made in 1915-16, but last season the excessive rain spoilt the crop.

In consequence of the insufficient supply of cane to the factory it worked only 54 days in 1915-16 and 44 days in 1916-17, consequently the cost of labour and fuel was much higher than it would have been, had the factory worked continuously for a season of four months, which is the average duration of a season in the United Provinces.

To return to the plant, it was found that the evaporating power of the plant was not equal to the crushing power of the mill, therefore it has been necessary to increase the plant by the addition of another film evaporator, which will bring the evaporating capacity equal to the crushing capacity of the cane-mill, and three crystallizers to do away with the earthenware vessels used for crystallizing, which proved to be inefficient. The new additions are expected to be erected in time for the season 1917-18.

Description of the Plant.

The cane-crushing mill (Plates II and III) is a compact arrangement of eleven rollers, and is capable of crushing one ton per hour (27·2 maunds). There are no intermediate carriers as is usually the case in multiple mills. These have especially been avoided to keep the price of the mill as low as possible. The cane in process of crushing passes by gravitation from roller to roller and is finally delivered on to the firing platform in front of the steam boiler, from whence it is thrown into a specially constructed megass furnace attached to the boiler. The dimensions of the rollers are :—The Krajewski rollers 9″ dia., top three $9\frac{3}{4}$″ dia. 15″ long ; middle three 10″ dia. 15″ long ; and bottom three $10\frac{1}{4}$″ dia. 15″ long. When crushing at the rate of 30 maunds per hour the extraction of juice from the inferior cane supplied averaged, in 1915-16, 62·5 per cent. for the whole period of the trials when out of 54 days the factory was worked 9 days with six rollers only (*see* Appendix), and in 1916-17 the extraction was 64·98 per cent. The sucrose extracted in juice from 100 in cane averaged 85·34 for the season 1916-17.

The juice on leaving the mill is strained through a sieve and passes into a tank from whence it is pumped to the top of a wooden chamber. In falling through this chamber the juice is broken up into minute streams by means of specially constructed obstacles fixed in the chamber.

Sulphur fumes, generated in a small furnace by burning sulphur, are made to travel upwards by means of a steam jet which induces a current of the sulphur fumes to mix with the juice. The object of this is to bleach the vegetable-colouring matter present in the juice, and have a heavier precipitate of lime salts in the clarifiers, which would effectively envelope the coagulated gums and pectines and settle with them at the bottom. The juice then falls into a tank where it is weighed and mixed with milk-of-lime to neutralize the acids present. The attendant uses litmus paper to guide him in neutralizing the juice. It is then pumped into the clarifiers, which are tanks, two in number, fitted with copper steam coils. In these the temperature of the juice is raised until a scum has formed, which is carefully removed and afterwards pressed to recover the juice it contains. After the scum has been removed flocculent particles of lime sulphite, sulphate, and other impurities in suspension gradually settle to the bottom. The clear juice is then decanted off by means of a pipe supported by a float, and run into a filter composed of specially woven cotton bags.

The juice coming from the filter is bright and clear and ready for concentration. This is done by means of a film evaporator (Plate IV), a vessel of copper in which revolves a cylinder made of copper pipes, which are heated by the exhaust steam from the engine that drives the cane-mill, etc., supplemented by a small quantity of steam direct from the boiler.

When the juice is concentrated to a given density (40° Beaume), specific gravity 1·383, it is ready for making sugar and is put into the crystallizers (Plate V) to grain out; or if it is intended to make *gur* it is further concentrated to about 44° Beaume, specific gravity 1·438, then poured into earthenware vessels, and is ready for sale in a few days.

After graining the sugar is separated from the molasses in a centrifugal machine (Plate VI), and after drying is ready for the market.

The molasses is boiled again and put into masonry tanks, where it remains until it crystallizes out and is again centrifuged. The sugar taken from this is called second sugar, and is darker in colour than the first sugar. The molasses from this is again boiled and again allowed to crystallize to get out as much sugar as possible. The sugar from this is called third sugar.

The scum and settlings from the clarifiers are put into a tank in which there is a steam coil. They are limed to alkalinity and boiled violently, and the clear alkaline juice is pressed out, leaving a solid cake

which is useful as manure. The juice from this residuum is mixed with the raw juice in the liming tank after it has been weighed. The filter press, however, proved to be too small to cope effectually with the scums when the factory worked day and night, and so the scums had to be run in filter bags. An experiment to find out the loss in filter bags mud, which analysed comparatively high, was carried on this season, and weights of mud were taken successively for several days. The average figures are :—

	Mds.	Seers.
Average weight of filter bags mud per day	5	10
Weight of mud on the weight of cane	1·6	per cent
Loss of sucrose in mud on cane	0·2	,,

The crushed cane—megass— is used for generating steam in a multi-tubular boiler. When the cane mill is working no other fuel is required, but when it is stopped wood fuel is necessary to keep up steam to drive the film evaporator and centrifugal.

Below are given figures to compare good and ripe canes with unripe and bad canes :—

	Good quality unripe	Good quality ripe	Ordinary quality unripe	Ordinary quality ripe
Variety of cane	J·33	J·33	Dhour	Dhour
Date of analysis	22nd Nov., 1915.	16th March, 1916.	18th Nov., 1915.	24th Feb., 1916.
Juice analysis—				
Sucrose	13·79	20·40	10·44	15·40
Invert sugar	1·69	0·32	2·32	0·89
Purity	81·85	91·48	75·22	87·00
Brix degrees	16·86	22·3	13·88	17·7

There is promise of a sufficient supply of cane to keep the factory working during the season 1917-18, and, if the cane is supplied, the factory will be tested as to the possibilities of success as a commercial concern, and a report showing the result of the season's work will be issued in due course.

At the time the foregoing Note was written, there was some doubt as to whether the new machinery then being made by the Canal Foundry and Engineering Works, Roorkee, would be ready and erected by the beginning of the sugarcane crushing season. This point has now been cleared up ; the three new crystallizers and the film evaporator are now erected at the Nawabganj Experimental Factory, and the steam connections will be completed in time for the new crop.

The cane has turned out to be very good compared with other seasons. The larger varieties grown on the Government farm are excellent, *Assami White*, *J. 33*, and *Ashy Mauritius* are particularly good in size and healthy. A small quantity of *Uba* has been destroyed by rust. It is possible that the above-mentioned varieties may be still further improved by deeper trenching and perhaps by using other manures than have been used on this farm previously, if so, there might be a chance of increasing the height of the middle figure in the diagram (p. 8), which if accomplished would be worth any number of experiments.

Now that it has been demonstrated that good cane can be grown in this district, the senior author ventures to suggest that it might be advantageous to continue the experiments both on the farm and in the factory, to find out the results that could be obtained by means of a FOURTEEN ROLLER MILL such as is used in other sugar-producing countries. The FOURTEEN ROLLER MILL has become very popular and may be said to be a standard type in other countries.

It is to be noted that (as far as the senior author knows) there are no fourteen roller mills in the United Provinces or Bihar ; the sugar factory proprietors have not ventured beyond eight rollers except in one case, nine rollers, and another eleven rollers.

The cane mill at the experimental factory at Nawabganj has eleven rollers, and it is suggested that a three roller unit be added and attached, which would make it into a fourteen roller mill, and that vacuum evaporation be adopted.

Most of the additional plant necessary for this experiment could be obtained in India, the whole of which, including housing, would cost about Rs. 20,000.

APPENDIX.

I. Statement showing Weekly Averages, 1915-16.

Factory started work on 6th December, 1915.

Week ending	Total cane crushed during the week		Total juice extracted during the week		Percentage of extraction	Average analysis of juice				Sucrose in bagasse	No. of working days in the week	Remarks
						Sucrose	Glucose	Purity	Total solids (Brix's)			
	Mds.	Srs.	Mds.	Srs.								
11th December, 1915	299	11	170	0	56·80	12·68	1·72	77·03	16·42°	5·34	3	With nine rollers.
	367	23	200	10	54·47	12·92	1·57	78·05	16·55°	6·71	3	With six rollers. One of the pinions of megass rollers broke down on the 8th on account of a piece of iron coming between the rollers.
18th December, 1915 .	1,163	15	645	10	55·46	13·17	1·81	76·52	17·25°	6·49	6	With six rollers.
25th December, 1915 .	342	24	188	35	55·12	12·40	1·82	75·91	16·30°	6·79	2	Closed for Christmas holidays as the cane was unripe.
1st January, 1916 . .	Holidays											
8th January, 1916 . .	1,078	9	688	15	63·84	13·78	1·38	78·29	17·53°	5·32	6	With eleven rollers for 4 days and nine rollers for two days.
15th January, 1916 . .	1,708	22	1,105	10	64·68	15·19	1·33	79·23	19·16°	5·40	6	With nine rollers. Night and day work started from 12th January, 1916.
22nd January, 1916 . .	1,974	15	1,277	25	64·70	13·60	1·72	78·65	17·23°	5·45	6	Farm cane unripe and so the analysis rather tends to go down.
29th January, 1916 . .	1,967	12	1,271	20	64·63	13·97	1·59	79·83	17·49°	5·52	6	
5th February, 1916 . .	773	35	496	20	64·15	13·80	1·38	80·07	17·23°	5·63	3	Worked night and day till 31st and then one day in the day only.
12th February, 1916. .	Closed											
19th February, 1916. .	680	5	431	10	63·40	14·40	1·43	79·04	18·21°	5·41	4	
26th February, 1916. .	1,120	9	705	20	62·97	15·20	1·58	77·45	19·62°	5·63	5	Worked day and night on the 23rd.
4th March, 1916 . .	424	9	260	0	61·28	14·39	1·76	79·00	18·78°	4·56	3	Crushing finished on the 2nd March, 1916.
26th March, 1916 . .	149	14	95	20	64·27	19·40	1·09	86·41	22·45°	6·37	1	J. 33 and other big canes specially supplied by the Government farm. With 11 rollers.
Total .	12,049	3	7,535	35	62·54	14·02	1·57	78·5	17·87°	*5·66	54	*Moisture 50·3. Out of 54 days the factory worked night and day for 18 days.

II. Statement showing Analysis of Products, 1915-1916.

(*i*)

Sugars				Gurs						Rabs					
Quality	Sucrose	Remarks		Quality	Sucrose	Invert sugar	Co-efficient of purity*	Total solids (Brix's)	Remarks	Quality	Sucrose	Invert sugar	Purity	Total solids (Brix's)	Remarks.
Refined sugar	99·7	Dry	Some of the sugars were sold without being dried and sieved. Some 9 mds. of very dirty sugar was refined.	First gur	69·6	10·10	77·77	89·49°	Those juices which were found to contain high glucose were boiled into gur. Experiments were tried to make gur out of molasses first and second both.	Rab in first masonry tank	46·7	18·42	57·65	81·00°	Mixture of the boilings of 1st and 2nd molasses.
J. 33 (cane) sugar	99·4	Nearly dry								Rab in second masonry tank	48·1	18·86	58·69	81·95°	Do.
First sugar, first quality	99·2	Dry		First molasses J. 33 gur	70·9	10·58	80·79	87·75°		First molasses rab (reboiled) in *kalsis*	54·4	19·55	61·15	88·95°	The first time boiling was not thick enough, so it was reboiled. In *kalsis*.
First sugar, second quality	98·6	Do.													
First sugar, third quality	96·7	Half dried		First molasses gur	57·2	17·71	64·19	89·10°		Second molasses rab	52·8	19·55	60·34	87·50°	Do.
Second sugar	97·6	Do.								Second molasses rab combined with filter press juice	54·2	15·87	63·91	84·80°	
Bad sugar, Roorie, etc.	91·0	Do.		Second molasses gur	52·2	19·0	57·80	90·30°							

(*ii*)

Stuff	Sucrose	Invert sugar	Ash	Water	Organic matters other than sugars	Co-efficient of purity	Rendement†	Total solids (Brix's)	Remarks
First molasses	51·00	9·82	..	..	..	69·11	..	73·94°	Average analysis.
Second molasses	39·63	19·69	..	..	..	50·52	..	78·48°	Do.
Juice	14·30	1·48	0·28	81·99	1·95	79·35	11·84	18·01°	Average full analysis.
Molasses	43·60	15·38	5·49	23·49	12·04	56·98	9·01	..	Full analysis of a mixture of 1st and 2nd molasses.
Filter bags mud	14·00	..	..	..	..	..	..	..	Taylor's bag filter began to work from 16th February, 1916.
Filter press mud	7·56	..	..	..	..	..	..	..	Filter press began to work from 26th February, 1916.

* Co-efficient of purity = Percentage of sucrose on the total solids.
† Rendement = Available sugar.

III. Statement showing the Analysis of Farm Experimental Cane, 1915-1916.

Month and Date	Variety of cane	Field number	Weight of cane crushed	Weight of juice expressed	Percentage of mill extraction	Total sucrose in cane	Percentage of sucrose extracted in juice from 100 in cane	Analysis of juice. Sucrose	Glucose	Co-efficient of purity	Total solids (Brix's)	Specific gravity of juice at 24° C.	Sucrose in bagasse	Remarks
			Mds. Srs.	Mds. Srs.										
January 1916 4	Kinar .	D. $\frac{1}{7}$	74 7	48 25	65·55	11·57	83·84	14·80	1·15	80·87	18·30°	..	5·42	
,, ,, 6	J. 33 .	C. $\frac{4}{6}$	37 14	25 20	68·27	12·24	86·27	15·47	1·88	81·76	18·92°	1·074	5·31	Sown on the flat (eaten by pigs and jackals fallen dry cane).
,, ,, 13	Saretha .	C. $\frac{3}{5}$	126 8	72 5	57·15	10·64	79·88	14·88	1·62	77·90	19·0°	1·074	4·99	
,, ,, 13	Do. .	C. $\frac{5}{1}$	114 23	77 0	67·20	The analysis was not done on account of the pressure of work.								
,, ,, 13	Do. .	C. $\frac{4}{1}$	101 22	65 35	64·87	11·71	84·69	15·29	1·48	77·45	19·74°	1·080	5·10	
,, ,, 14	Do. .	C. $\frac{4}{1}$	125 14	82 10	65·61	12·88	83·77	16·46	1·07	82·63	19·92°	1·081	6·05	Comparatively unripe. A few sticks of this on 25th February, 1916, gave analysis of juice :— Sucrose Glucose Purity 18·80 0·88 87·03 Brix degrees. 21·6.
,, ,, 17	Kagzi .	C. $\frac{1}{5}$	150 18	102 15	68·04	10·17	83·35	12·46	2·11	77·58	16·06°	1·061	5·31	Quite unripe. *Rab* made from it was very slow to crystallize out. Analysis of *rab* is— Sucrose Glucose 61·4 8·86.

,,	,,	18	Dhour	.	C. 1/2	143	33	97	15	67·70	11·16	83·16	13·71	1·65	80·65	17·00°	1·065	5·84	Unripe.
,,	,,	20	Kagzi	.	C. 1/3	143	28	94	0	65·41	8·91	81·03	11·05	2·32	72·12	15·32°	1·059	4·89	Quite unripe.
,,	,,	21	Saretha	.	C. 2/1	106	6	68	5	64·18	12·57	85·76	16·80	0·75	85·45	19·66°	1·078	4·99	
,,	,,	22	Dhour	.	C. 3/2	120	34	83	5	68·79	10·44	83·52	12·68	1·79	78·32	16·19°	1·063	5·52	Quite unripe.
,,	,,	24	Neora	.	C. 4/6	131	32	84	20	64·11	11·32	81·53	14·40	1·93	77·41	18·60°	1·076	5·84	Unripe.
,,	,,	25	Dhour	.	C. 4/3	139	0	91	25	65·91	11·05	82·96	13·91	1·79	79·44	17·54°	1·070	5·52	Do.
,,	,,	26	Kuswar	.	C. 4/6	53	32	37	10	69·23	..	..	12·10	1·70	77·91	15·53°	..	..	
,,	,,	27	Dhour.	.	C. 2/2	122	21	79	35	65·19	11·72	82·34	14·81	1·19	84·67	17·49°	1·070	5·95	Unripe.
,,	,,	28	Kagzi	.	C. 2/3	49	14	31	10	63·32	10·86	82·09	14·08	1·55	81·38	17·30°	1·068	5·31	Do.
,,	,,	29	Khari	.	C. 4/5	52	13	34	10	65·45	11·07	85·07	14·39	1·86	81·76	17·60°	1·070	4·78	Do.
,,	,,	30	Kagzi	.	C. 3/4	28	37	19	0	65·68	11·52	83·23	14·60	0·91	83·43	17·50°	1·070	5·63	
,,	,,	31	Do.	.	C. 3/3	20	25	13	0	63·03	10·30	82·26	13·20	1·67	79·52	16·60°	1·064	5·10	Unripe.
March	,,	2	Dhour	.	C. 3/4	49	29	31	35	64·10	9·43	84·62	12·46	2·03	72·06	17·29°	1·067	4·03	Diseased cane, a few good sticks from this, on 24th February, gave analysis of juice :— Sucrose 15·4 Glucose 0·89 Purity 87·0 Brix degrees. 17·7.
,,	,,	26	J. 33	.	C. 5/6	127	19	80	15	63·05	14·58	83·88	19·40	1·09	86·41	22·45°	1·095	6·37	Sown in trenches. Lying for 12 hours before it was crushed. Fresh sticks, on 16th March, gave analysis of juice :— Sucrose 20·40 Glucose 0·32 Purity 91·48 Brix degrees. 22·3.

IV. Statement showing Average Analysis of Products, 1916-1917.

(*i*)

Sugars			Gurs				Molasses					
Quality	Sucrose	Remarks	Quality	Sucrose	Invert sugar	Remarks	Quality	Sucrose	Invert Sugar	Co-efficient of purity	Total Solids (Brix's)	Remarks
First sugar (first quality)	99·30	From the crystallize, dried in the laboratory	First gur	76·11	6·42	From cane juice direct	First molasses	45·32	14·11	57·80	78·53°	Molasses from juices slightly acid to litmus paper. This was made into *gur* but had to be remelted as it could not be sold.
First sugar (second quality)	98·60	From *kalsis*, dried in laboratory	Second gur	71·45	7·40	Mixture of juice and first molasses	Do.	55·02	6·17	75·38	73·01°	Molasses from juices slightly pinkish to phenol-phthal e i n. This was made into *rab* again.
Second sugar .	97·30	..	Third gur	64.27	11·15	First molasses gur	Second molasses (thick)	46·56	14·40	58·82	79·23°	Contained no washings.
Third sugar .	95·70	..	..	..	..	..	Second molasses (thin)	48·40	7·02	73·24	65·90°	Washings after the thick molasses had gone out.
Roorie . .	90·2	Small lumps of sugar with bits of *kalsis*	..	..	..	..	Third molasses	43·80	14·51	54·95	79·70°	

Stuff	Sucrose	Invert sugar	Ash	Water	Organic matters other than sugars	Co-efficient of purity	Total solids (Brix's)	Rendement*	REMARKS
Second sugar . .	97·10	0·45	1·21	0·72	0·52	97·8	..	..	Full analysis of a sample of sun-dried sugar.
First *gur* . . .	77·20	5·87	2·70	..	..	..	..	57·83	Average analysis.
Second *gur* . .	71·60	7·19	3·05	..	..	..	..	49·15	Average analysis.
Third *gur* . .	66·00	11·50	6·25	9·50	6·75	72·92	..	32·63	Full analysis of a sample.
First molasses . .	44·60	14·16	5·62	25·65	9·97	59·98	..	10·77	Ditto.
Second molasses .	44·80	15·66	5·67	21·05	12·82	56·75	..	9·30	
Juice . . .	15·35	1·34	0·47	80·82	2·07	80·03	19·18°	12·81	Full average analysis of a few samples.
Filter press mud .	9·58	..	..	..	..	..	..	..	Average analysis. The filter press was found insufficient to cope with the scums, when the Factory worked day and night, and so it only worked for about a week.

* For 1st and 2nd *gurs*, which was sold to Pilibhit Factory, the formulæ, Sucrose—(5 ash + Invert sugar) has been used. For others the usual formulæ, Sucrose—($3\frac{1}{2}$ ash + Invert sugar).

V. Statement showing Weekly Averages, 1916-1917.

Factory started work on 6th December, 1916, at 4 p.m.

Week ending	Total cane crushed during the week	Total juice extracted during the week	Percentage of extraction	Average analysis of juice.				Sucrose in bagasse	Sucrose in filter bag's mud	Number of working days in the week	Remarks
				Sucrose	Invert Sugar	Co-efficient of purity	Total solids (Brix's)				
	Mds. Srs.	Mds. Srs.									
9th December, 1916	438 13	287 15	65·56	13·94	1·39	78·66	17·72°	5·85	10·60	4	Working in the day only.
16th December, 1916	The factory remained closed.										
23rd December, 1916	(i) The chimney was raised up, as the draught was insufficient, the fan having broken.										
30th December, 1916	(ii) The Sugar Engineer Expert went to Peshawar to consider the question of sugar manufacture in N.-W. F. Province.										
6th January, 1917	(iii) Christmas Holidays.										
13th January, 1917	1,617 29	1,057 5	65·35	14·00	1·47	77·37	18·09°	4·76	10·70	6	Working day and night.
20th January, 1917	1,909 2	1,196 30	62·69	14·10	1·86	75·86	18·59°	4·64	11·64	6	Ditto.
27th January, 1917	1,820 20	1,168 10	64·17	15·40	1·64	77·66	19·82°	5·03	12·02	6	Ditto.
3rd February, 1917	1,336 38	871 15	65·17	14·92	1·33	79·34	18·80°	4·83	11·90	5	Ditto.

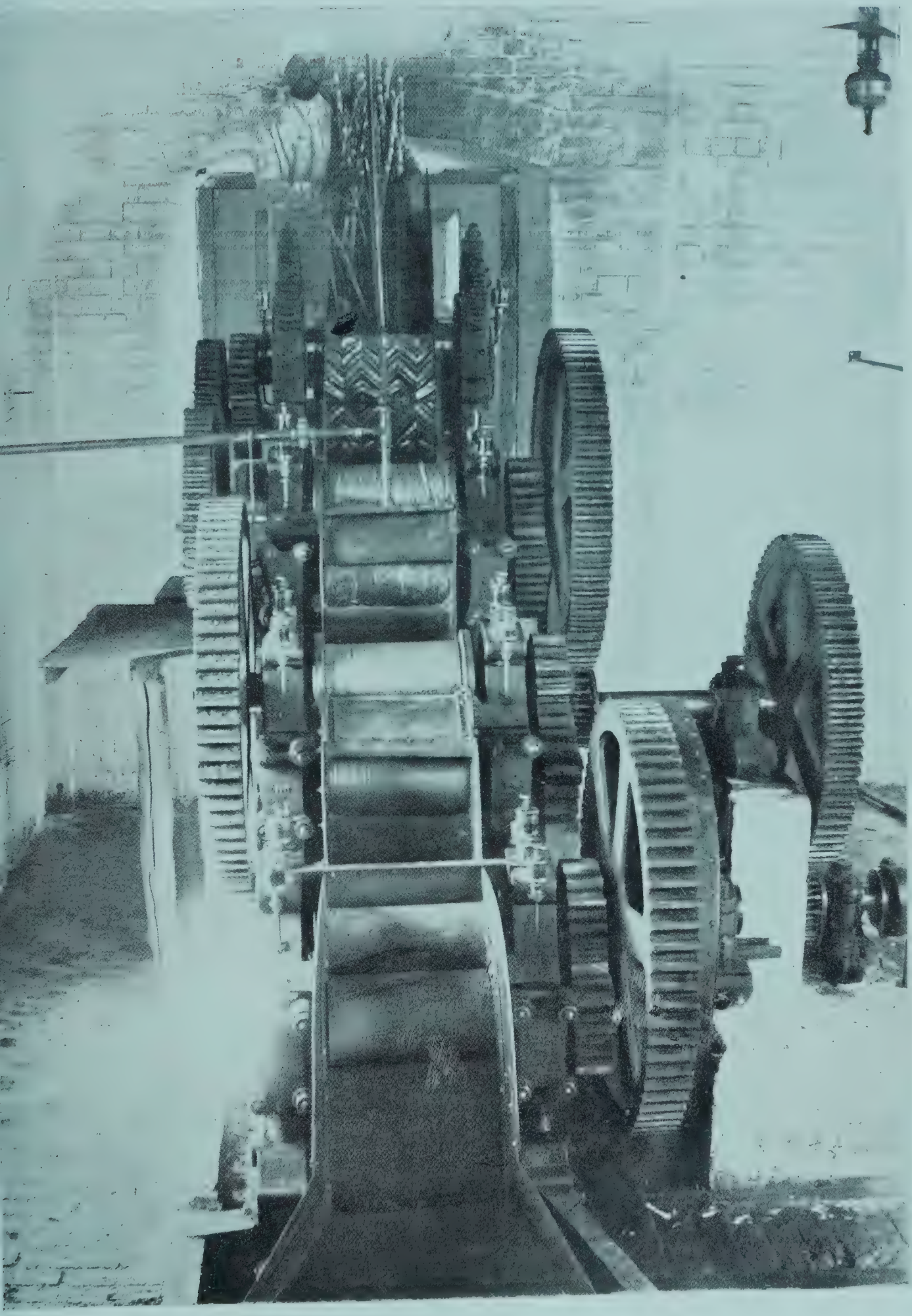
10th February, 1917	538 5	360 5	66·92	13·97	1 52	77·90	17·93°	5·41	12·80	4	Worked in the day only. The weather was very rough during the week. Heavy rains and high winds prevailed throughout. 71 maunds 37 seers of cane at the factory and some at the fields was lying for 48 hours before it could be crushed. No carts were available to cart cane. That is why the Brix has appreciably gone down.
17th February, 1917	636 22	397 0	62·37	14·78	1·41	78·60	18·81°	5·43	12·90	5	Day only. The cane supply to the factory lessened.
24th February, 1917	93 7	63 5	67·74	15·90	1·65	77·79	20·44°	5·84	12·40	1	Village cane finished.
3rd March, 1917	430 28	310 20	72·92	15·43	0·93	81·72	18·88°	5·47	13·80	3	All farm cane, Uba and Agaul varieties.
10th March, 1917	273 31	191 35	70·08	14·77	1·20	79·14	18·64°	5·18	14·20	3	Ditto.
17th March, 1917 to 24th March, 1917	Cane season was practically finished. The time was occupied in remelting *gur*, which was made out of the 1st molasses and which could not find sales on account of the prejudices of the people who would buy nothing but *bhelis* or *gur* in lumps										
31st March, 1917	95 36	66 5	68·95	18·10	0·41	88·03	20·56	5·21	14·60	1	Thick Pounda canes from the Government farm.
7th April, 1917	205 12	136 15	66·42	No chemical analysis was done. Things were packed up.							
TOTAL	9,396 3	6,106 0	64·98	14·66	1·45	78·36	18·70	5·13	12·24	44	Out of 44 days, the factory worked day and night for 23 days.

VI. Statement showing the Out-turn for 1916-17.

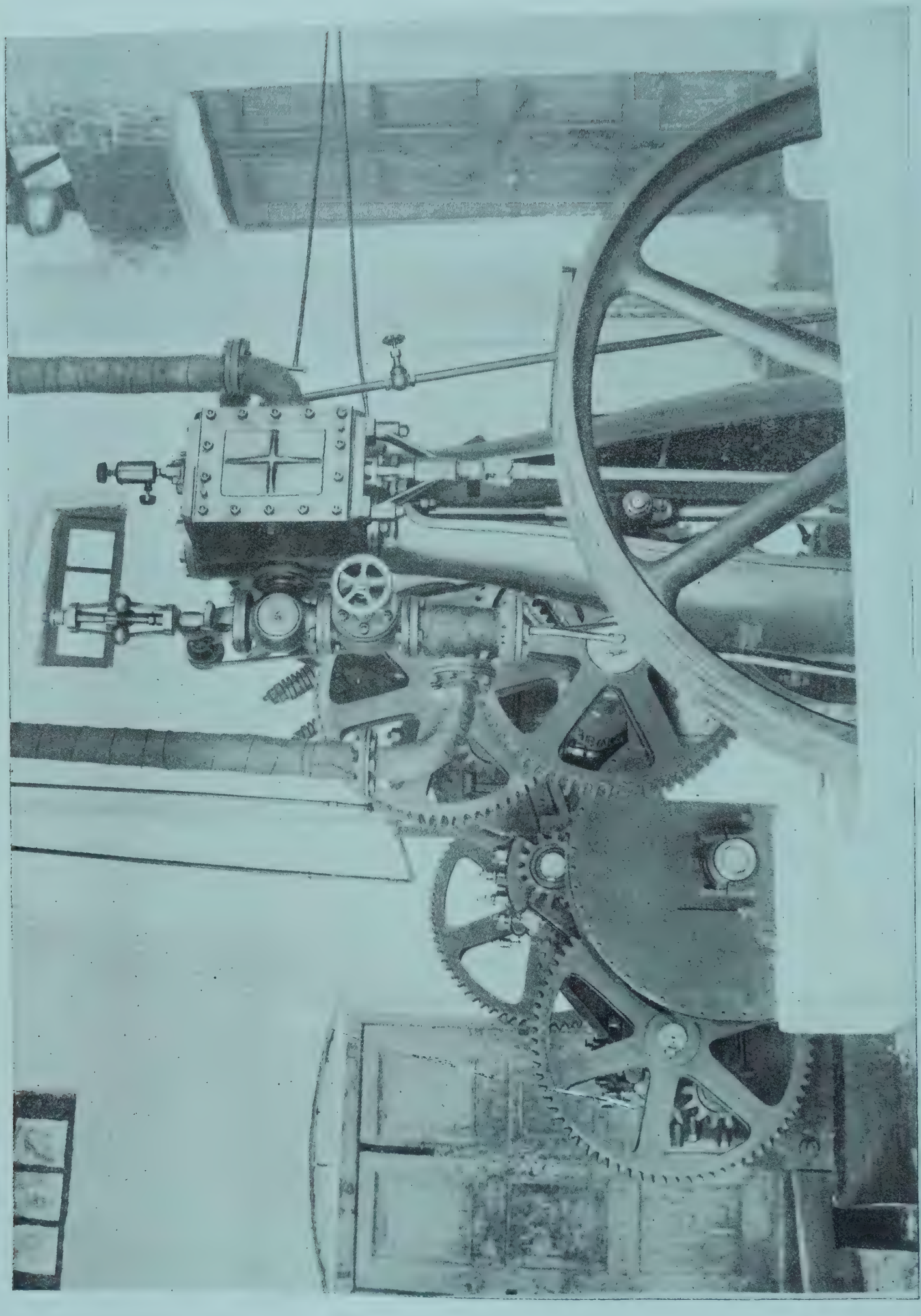
	Mds.	Srs.	Chs.	
I Sugar	177	28	15	
II „	33	17	0	
III „	2	15	0	
Roorie	9	36	12	
	223	17	11	
1 Gur	377	27	12	
I and II molasses *gur* in *bhelis* . .	4	18	8	
Rab in tank (sold)	134	35	0	
Rab in *kalsis* (267)	93	18	0	calculated.

Fig. 1. EXPERIMENTAL FACTORY, BAREILLY.

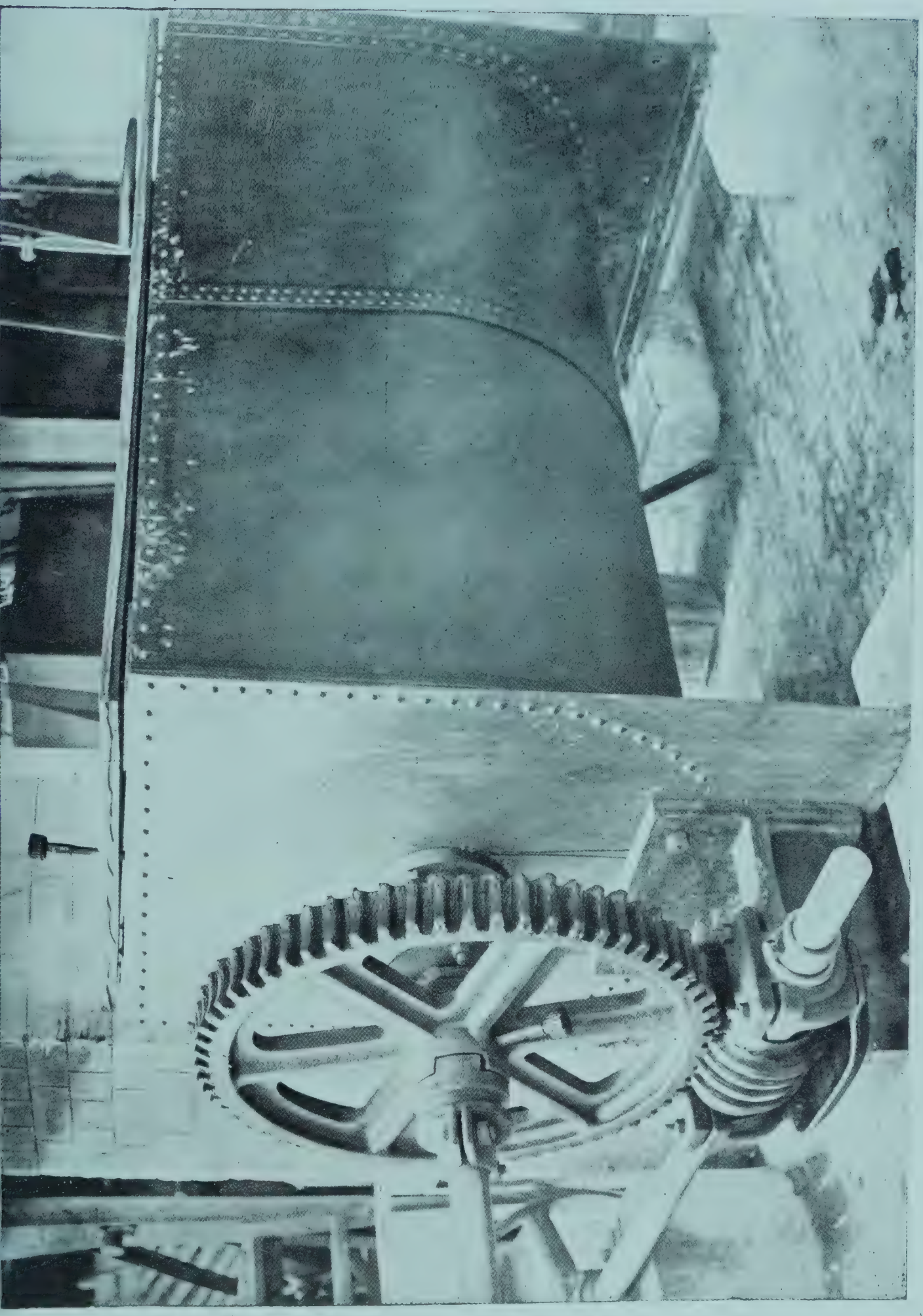
Fig. 2. LAND PREPARED FOR SUGARCANE.



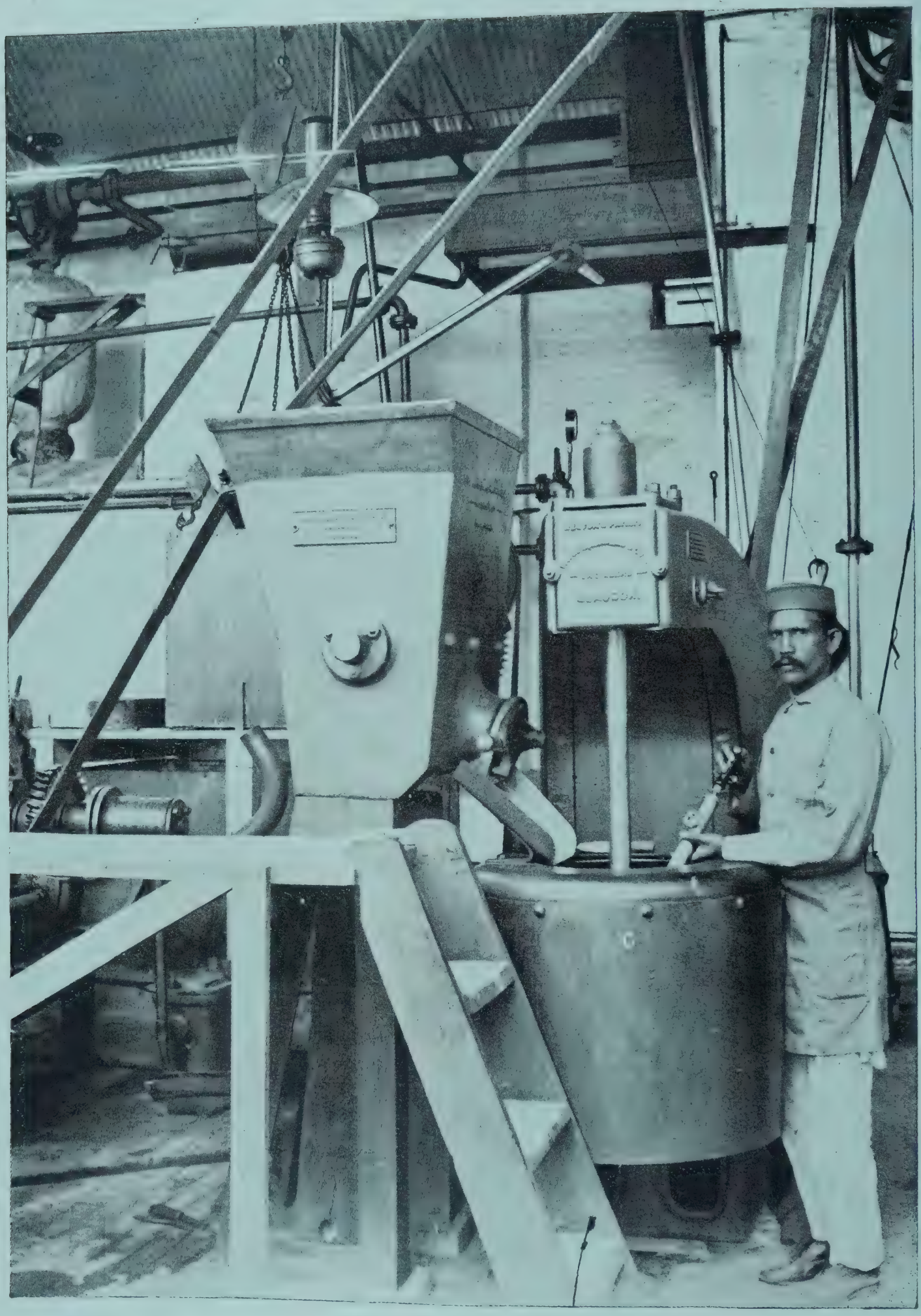
FRONT VIEW OF CANE MILL.



FILM EVAPORATOR.



CRYSTALLIZER.



A, PUG MILL; B, LIMING TANK; C, CENTRIFUGAL MACHINE.

A, SULPHUR FURNACE; B, CLARIFIERS; C, BOILER; D, MEGASS FURNACE BELOW THIS.

INTRODUCTION

IT has been the custom in the past to collect the mass of notes prepared on the special subjects discussed at the meetings of the Board of Agriculture and to print them as appendices to its Proceedings. When it was decided on the last occasion to abbreviate the Proceedings by leaving out most of these notes, and thus keep the bulky volume within reasonable limits and also issue it more expeditiously, the Agricultural Adviser was approached as to the possibility of printing the notes on the progress of the sugar industry as a Bulletin of the Pusa Research Institute. This form of publication is, after all, much more suitable, for the Proceedings are often not readily available and the information contained in the appendices is liable to be overlooked. Thus far the notes on the sugar industry prepared for each meeting of the Board have been preserved and it was felt that it would be a pity to break the continuity of the record. The Agricultural Adviser has kindly agreed to this suggestion and has asked me, as Chairman of the Sugar Committee, to edit the bulletin and write an introduction. The note on the work of the experimental factory at Nawabganj, in the United Provinces, is not printed here, as it has been issued as a separate bulletin[1]. No notes were received from Bengal and the North-West Frontier Province, but these have been subsequently prepared at special request, and are included with the rest.

On looking through the reports presented on this and previous occasions for discussion at the Board of Agriculture, the first thing that will strike any one interested in the progress of the sugar industry in India is the marked inequality of the amount of information recorded regarding different tracts, the amount of detail in no way corresponding to the importance of the work being done or the interests involved. This is, of course, partly a natural expression of the amount of personal attention given to the subject by the different authors of the notes. Some few of them are devoting their whole attention to sugar matters, while others have many other interests to engage their attention. Some of the notes have been written by chemists, botanists or agriculturists, and the point of view differs accordingly, whereas a number have been prepared by Directors of Agriculture, who are in charge of all the

[1] *Agric. Res. Inst., Pusa, Bulletin* no. 82.

activities of their Departments, and cannot therefore be expected to possess the detailed knowledge of the subject which is desirable.

As instances of the meagreness of the information presented concerning important tracts, the reports printed here of the Directors of Agriculture in the United Provinces and Bihar and Orissa may be specially referred to. In the former case, with a greater acreage under sugarcane than the whole of the rest of India put together, the work of the Shahjahanpur Research Station is practically unnoticed, doubtless in part due to the absence of Mr. Clarke from India at the time. The whole of the cultural and varietal work being carried out in the province is dealt with in one short paragraph, although, as will be seen later, the Director regards this as the most important part of the sugar work of the Department. In the report from Bihar, where the greatest number of the sugar factories in India are collected, no reference is made to their work at all. This will naturally be read as an indication that the Agricultural Department is not in touch with them; but a very much fuller and more useful report might have been presented by the Agricultural Chemist, who has devoted much time to sugar matters and done a good deal of useful work on the subject. The Bombay note contains no reference to the extremely promising and important extension of the sugarcane area in the tracts of the Deccan now being opened up by the new system of canals, although a newspaper cutting was afterwards added, at special request, by the Director of Agriculture, containing a summary of his evidence before the Indian Industrial Commission. The Burma note contains no information as to the progress of the Government scheme of opening up a new sugarcane area in the Mon Canal region. But instances need not be multiplied to demonstrate the very partial nature of the information placed before the Sugar Committee by the local authorities. The Committee expressed itself freely on the subject[1], and a general study of the material printed in this bulletin will furnish a strong condemnation of the system at present adopted, as it no longer meets the needs of the case. What is wanted is a much more thorough study of the industry from all points of view, and this bulletin presents a powerful argument for the formation of the Bureau of Sugar Information which the Board of Agriculture proposed should be started, consisting of specialists whose whole time should be devoted to the various aspects of this important industry throughout India.

That the sugar industry in India is in need of immediate attention is agreed to everywhere, and that this is fully realized by Government is obvious from the remarks of Sir Claude Hill in his opening address

[1] *Proceedings of the Board of Agriculture in India, Poona, 1917*, p. 78.

at the Poona meeting of the Board of Agriculture.[1] It is instructive to note the somewhat divergent views which are held, by different authorities, as to the special defects which are held to be fundamental, and which should be immediately attended to if any hopes of improvement are to be entertained. The process of manufacture of the raw product is admittedly of a very primitive nature and, although there is a steady improvement in many places, it is the belief of some that this is the limiting factor which must be attended to before any improvement can be hoped for. This point of view is a century old, and has recently been specially advocated by Mr. Sayer in a series of articles in the *Agricultural Journal of India*.[2] The principles of *gur*-making are undoubtedly in many places woefully wasteful, if not radically wrong. But is not this point of view to a certain extent influenced by the translation of *gur* into white sugar? The ryot prefers this *mixture*, and is even content to pay a higher price for it than for the pure white sugar. Looked at from this point of view, the loss in manufacture is perhaps somewhat exaggerated. The cultivation accorded to the sugarcane in a large part of India is also extremely primitive. For its improvement, much propaganda work is needed by the Agricultural Department, but this is complicated by the facts that it is extremely difficult to alter, by example or precept, agricultural practice which is firmly rooted, and that the treatment of the canes in the tropics is largely inapplicable to the canes grown in India. It is the opinion in some quarters that, before the cultivation is improved, it is comparatively idle to attempt the introduction of better varieties. Thus, in his note for the United Provinces, Mr. Hailey writes: "The main work of the Department is concentrated on teaching the people better methods of planting and cultivation, and it is believed that when these are more generally in force, the introduction of better classes of canes will necessarily follow; but, until adopted, the best results will not be obtained from the work on the research farm in this province or that at Coimbatore." Lastly, the kinds of cane grown all over the great sugarcane tract of India are easily the worst in the world, and it is believed by some that this is the basal defect in the industry and that, if better kinds are forthcoming, they will be readily taken up by the cultivator, and that improved cultivation and manufacture will be more likely to follow, when the increased production places the ryot in a better financial position. This is the object with which the Coimbatore farm was started. There is no doubt that the great expansion in the sugar industry in the Madras Presidency, during recent years, is mainly due to the good new

[1] *Proceedings of the Board of Agriculture in India, Poona, 1917*, p. 19.

[2] Vol. XI, pts. I and IV; and vol. XII, pt. IV.

kinds of cane introduced through the agency of the Samalkota farm in the Godavari District, and nowhere is this more forcibly exhibited than in the fine sugar factory at Nellikuppam in the South Arcot District.

These three lines of improvement are being continuously studied in all places where the Agricultural Department interests itself in the improvement of the sugar industry, as will be sufficiently obvious if we read between the lines of the various notes brought together in this bulletin. Which direction of work is the more urgent will depend largely on the locality and the conditions of the industry in it, but the general question is of more or less academic interest, for all three are being simultaneously followed in each province. It is, however, none the less a defect that these efforts are detached and independent, little being known in one province of what is being done in another, what methods are being adopted and what lines of work have been found to be most successful. And it is this fact that has led the Board of Agriculture unanimously to support the suggestion of the Sugar Committee that an Imperial Sugar Bureau should be formed, whose duty will be to collect and collate the results obtained in various directions, and thus to be in a position to assist the isolated efforts in different parts of the country with sound advice, based on experience gained by a general survey of the work done in India now and in the past, and that accomplished in other countries.

C. A. BARBER,
Chairman of the Sugar Committee
of the Board of Agriculture in India, 1917.

COIMBATORE ;
25th September, 1918.

Progress of the Sugarcane Industry in India during the years 1916 and 1917

(1)

MADRAS.

(*a*)

(G. A. D. Stuart, I.C.S., *Director of Agriculture.*)

A note by Dr. Barber on the progress at the Cane-breeding Station is appended, and also a note by the same officer on the general question of the possibility of increasing the production of sugar in India, originally prepared in 1916 for the Industrial Commission.

The testing of varieties at five agricultural stations has continued. On the East Coast, B. 3412 has been found to give a good yield of high quality jaggery, 4·6 tons to the acre, but this cane is soft and very liable to disease when grown under the water-logged conditions of the paddy area. Another variety, J. 247, which is a harder cane giving a somewhat smaller yield, appears to be immune to red-rot, and for this reason is likely to prove of great value in these areas. District work has consisted of the introduction of proved varieties, and the advocacy of smaller seed-rate and planting in rows where these practices are unknown. Iron mills are now universally used, but the local *jaggery*-boiling furnaces are often wasteful of fuel and the Department has been successful in getting these improved in places. In parts of the South Kanara District on the West Coast the cane is grown by sub-tenants who are too poor to manufacture *jaggery* and so sell their cane at low rates to professional *jaggery*-makers. An attempt is being made to start co-operative manufacture by the growers.

Two experimental *jaggery*-making plants, each consisting of a twelve horse-power oil engine, a 12 inches three-roller mill, and a battery of *jaggery* pans, were taken over from the Department of Industries last year. Full figures of production and cost had not always

been properly maintained in the past. Those obtained last year showed that the net cost of making *jaggery* from cane carted to the factory by ryots came to Rs. 2-2-0 per 250 lb. of *jaggery* made.

Messrs. Parry & Co. have continued to expand their manufacture of sugar direct from cane at Nellikuppam. They are employing steam tackle for the wholesale cultivation of land taken on lease from ryots. They have succeeded in persuading these to allow their field boundaries to be obliterated for the period of the lease, the boundary marks being sunk below the soil. Owing to the high price of *jaggery*, *jaggery*-making plants have been set up in the neighbourhood, however, and the company has had at times some trouble with particular cane-growers. But there has been no difficulty in securing as much cane as could be dealt with. The same company has commenced the manufacture of *massecuite* direct from cane at Anakapalle, the product being sent for refinement to their sugar factory at Samalkota. A similar sub-station is also working at Palghat in connexion with the Nellikuppam factory.

September, 1917.

NOTE. The following information has been received from the Manager of the Nellikuppam factory in South Arcot :—

OUT-STATION CRUSHING PLANTS.

We have installations at Valavanur and Tiruvannanallur. Each installation is equipped with three crushing sets, each set consisting of a three-roller mill directly coupled to a 10 horse-power steam engine and estimated to deal with 2 acres of cane per diem, *i.e.*, 6 acres per installation per diem. The juice from the mill passes *viâ* a tubular juice heater (heated with exhaust steam of engine) to a transit evaporator (open fire) and finally to a steam finishing pan where it is boiled to the required density to make into a dry brown sugar, which is subsequently refined.

We can deal with about 1,400 acres thus.

(*b*)

Progress Report of the Cane-breeding Station.

(C. A. BARBER, SC.D., *Government Sugarcane Expert.*)

Since the last meeting of the Board of Agriculture (in February 1916) a Memoir[1] has been issued containing details of the first three years' work on the Cane-breeding Station at Coimbatore. This contains also a fairly full study of the cane seedlings obtained during that period.

In this Memoir the character of the land was reported on, and it was shown that the acclimatization of the cane varieties collected on the

[1] "Studies in Indian Sugarcanes, No. 2. Sugarcane seedlings, including some correlations between morphological characters and the sucrose in the juice." *Mem. Dept. Agri., India, Bot. Ser.*, vol. VIII, no. 3.

farm was far from complete. Special attention has been paid to this point and the layers of soil in various parts have been studied to a depth of six feet. It has been concluded that the main fault in the land is due to the rise of saline substances due to evaporation after rain or irrigation. This is being countered by green-manuring and by keeping the soil covered as much as possible, especially where cane is being grown. The result of this work has been satisfactory, the growth of canes and seedlings is good, and the acclimatization of the cane varieties may now be considered as complete.

Such being the case, it has been found possible to make a comprehensive study of the varieties of the indigenous canes collected. A paper has been prepared and submitted for publication as a Memoir[1] which, it is thought, will go far to solving the many difficulties in the classification of Indian canes. Studies have also been instituted in the mode of branching of the different varieties, and the growth of canes in different localities and under different conditions.

The special methods adopted to induce the canes to flower and thus produce seedlings have been greatly assisted by their fuller acclimatization, as will be seen from the following figures :—

Cane varieties flowering on the farm.

	Thick canes	Thin canes	
1912-13	3	3	
1913-14	0	0	Farm not fully laid out.
1914-15	5	4	
1915-16	35	36	Exceptionally favourable weather.
1916-17	63	34	

The natural result of this increased flowering has been a remarkable increase in the number of seedlings obtained. During the 1916-17 campaign, as many as 99,000 seedlings germinated, more than thrice those obtained in any previous year.

But the ideal seedling aimed at is a cross between a thick tropical and a thin indigenous variety, and success in this has hitherto been comparatively small. We have worked out a ready means now of determining male fertility in any arrow or variety, but the great stumbling block in cane seedling work has always been the absence of any criterion as to the female fertility of the flowers. The subject has

[1] "Studies in Indian Sugarcanes, No. 3. The classification of Indian canes with special reference to the Saretha and Sunnabile groups." *Mem. Dept. Agri., India, Bot. Ser.*, vol. IX, no. 4.

been carefully studied by my first assistant and, apparently, successfully solved by the observation of the starch grains present in the stigmas. Besides this difficulty, the thick canes do not usually flower at the same time as the thin ones and, as the result of first five seasons' work, we managed to obtain less than 300 *probable* true crosses. With the convergence of all our lines of work, we have succeeded in the 1916-17 campaign in obtaining some 4,000 undoubted crosses of the desired nature. This is perhaps the outstanding piece of progress in the work of the Cane-breeding Station, and some 2,800 of these crosses are being grown on for analysis in 1918.

The whole of the sugarcane tracts in India have now been visited, at any rate partially, and we know fairly well what kind of seedling is likely to be useful in each of them. The most recent tract visited was Burma, and the result of that visit has been to convince us that the prospect of increase in acreage is more promising there than elsewhere, that the country is specially suited for the growth of thick canes, and that there is no inherent difficulty in the making of sugar on a large scale, if it is desired by Government to encourage the industry. A note has been prepared for the Industrial Commission on the subject of sugar production in India.

July, 1917.

(*c*)

Note on the Possibility of India's Producing its own Sugar or Becoming an Exporting Country.

(C. A. Barber, Sc.D., *Government Sugarcane Expert.*)

I. The present High Price of Sugar and the Question of its Permanence.

There is a marked shortage in the supply of sugar all the world over. This appears to me to be due to two main causes. In the first place, there is a rapidly increasing consumption *per capita* in all countries, and, secondly, the huge supplies of beet sugar, hitherto exported from Germany, Austria, and France, have been entirely cut off by the war. The world's pre-war consumption was about 18,000,000 tons yearly, and beet and sugarcane were credited with about 9,000,000 tons each. The price of sugar is at present extremely high, and I regard as probable that the longer the war lasts the higher will it rise.

India has, as is well known, imported increasing quantities of sugar during recent years, the annual total reaching not far short of a million

tons. This imported sugar used to come largely from Austria, more recently Mauritius entered the market, but at present it comes almost exclusively from Java. The world's shortage has made itself felt in India in that the retail price has nearly doubled. Can India, taking advantage of this, produce this sugar herself? Can she indeed look forward in the future to becoming an exporting country as she once was?

There are two basal factors to be considered before approaching this question. We do not know whether this rise in price will be more or less permanent, or whether, after the war, it will sink again to its former low level, and it is not an easy matter to start a sugar factory, and several years must elapse before the solid foundations of such an enterprise can be laid. Sugar-making in India must be considered to a large extent as a new industrial enterprise, and the difficulties in the way are much greater here than in any tropical country where the cane is grown. A vital question is the price of sugar after the war. I have formed the opinion that it will take many years before it sinks to pre-war level, if it ever does. And I base this opinion on the following facts and considerations :—

(1) There is a constantly increasing consumption of sugar in all countries, and one effect of the war will be, I think, to give an impetus to this. I regard this increase as a permanent feature for many years to come.

(2) It seems probable that the British Government will take some steps to prevent the free dumping of sugar on the market by countries at present at war with us, and this will inevitably lead to an enhancement of the price.

(3) There is a considerable dislocation in the beet-growing area in Europe, because the war has selected for its activities the particular area where beet is grown, and there has been a great and calculated destruction of property there. There will thus be less total sugar available. There is considerable shortage, even in Germany in spite of the cutting off of the whole of her export trade, and one of the lessons of the war will, I believe, be that it will be considered economical for much more sugar to be retained for internal consumption, both by man and beast, than was formerly done, in all beet-growing countries.

(4) With one exception of importance, to be noted below, I do not apprehend any immediate great extension of sugarcane tracts in the tropics. The following is, according to my idea, the position of affairs. There

are a very great number of countries in which the sugarcane is grown, and great strides have been made, both in field and factory, during the last twenty years of agricultural revival. It does not seem likely that further improvements or extensions will be more than sufficient to keep pace with the normal increasing demand, with one possible exception. For the sake of brevity, I will merely consider Java and Cuba, easily the greatest producers at the present time. There are many reasons for thinking that Java has nearly reached the limits of its production, as the past few years, in spite of strenuous scientific control, have shown decreased out-turn on the estates, and it is generally conceded that practically all the good sugarcane land has already been taken up. With Cuba it is different. It is a great unknown factor. But there are interesting figures available which show that this country is worthy of special attention. It is, indeed, quite within the bounds of possibility that, in the near future, it may dominate the sugar position much as Brazil has done that of coffee. It has not, moreover, as yet been possible or necessary to bring to bear on it the laborious scientific work which has characterized the industry in Java, Mauritius, the West Indies, Louisiana, Hawaii and other places. It will be seen from the following figures that there is a great future in store for the Cuban sugarcane crop.

Cuba's sugar production.

Before the war of 1898, it had reached 1,000,000 tons a year.

1897-1900	200,000 to 300,000 tons.
1901-1903	600,000 to 1,000,000 tons.
1904-1912	1,000,000 to 2,000,000 tons.
1913-1916	2,000,000 to 3,000,000 tons.

It is considered by some that the output this year may reach 3,500,000 tons. There are, I believe, great areas of rich land at present unworked, and capital and machinery are pouring into the country. There is little doubt that an important factor is thus introduced, which may have great influence on the future price of sugar.

II. The Difficulties in India.

(1) *The class of canes grown in India.* Roughly speaking, there are two great sugarcane tracts in India, which differ fundamentally. The

first is that in which thick tropical canes can be grown to maturity, often as well as in Java or the West Indies, the second is entirely given up to thin, hardy, fibrous, indigenous varieties generally unsuited for the economic production of sugar.

The first region consists of the Peninsula (Madras, Mysore, the lower parts of Bombay and the Central Provinces) and, curiously enough, Assam and Burma. This is the natural sugarcane tract and is, in the main, in the tropics. The inclusion of Assam is due to its moist, equable climate, in which it resembles, perhaps more than any other part of India, the cane conditions of such a tropical island as Antigua.

The second region is extra-tropical. Bengal and Bihar may be regarded as transitional, but, after passing the Rajmahal range of hills, a great change is noticeable in the character of the flora and the crops grown. We soon enter the wheat region, as contrasted with that of sugarcane. This region includes the alluvial plains of the Ganges and Indus and extends into the north of the Central Provinces and probably of Bombay.

Now it is a curious fact, and a constant source of mystification to those not conversant with Indian conditions, that the acreage under cane in the sugarcane tract is comparatively insignificant, and at least 90 per cent. of it is to be found in what I have summarily termed the wheat tract. This is one fundamental difficulty in any extension of sugar-making in India. I am not prepared to discuss its causes in detail here, but would merely suggest that in the past, with comparative lack of communications and the presence of hardy indigenous kinds, the need of sugar or its equivalent *gur* caused the sugarcane to become an integral part of the cultivation in North India, whereas the smaller populations of the south were more accessible from outside and had other sources of supply in their palm forests. Furthermore, irrigation was necessary there, and the expenses generally of cultivating the thick tropical canes were out of all proportion greater than those of the northern kinds, and this undoubtedly checked expansion in the south.

(2) *Competition with gur.* Besides the unsuitable character of the canes grown, a second difficulty in the way of extension of sugar-making in India is the fact that, beyond the importation referred to above, sugar is not an essential food of the people. They prefer *jaggery* or *gur*, an extremely impure form of sugar, which cannot, as a rule, be economically used as a raw material for sugar-making. The great mass of the sugarcane grown in the country is used in the preparation of this commodity. The price is comparatively unaffected by the fluctuations in the world's sugar market, and the chief factors influencing the extension of cane cultivation are the general increase

in population and the rise in the scale of living, the character of the season, and the prices of such other staples as are grown interchangeably with it. The relative profitableness of the conversion of the cane juice into *gur* and sugar has therefore to be considered in each tract before any decision can be reached as to the possibility of founding a sugar factory there. I am not in a position to discuss this question in its commercial aspects, but would merely draw attention to the fact that the contest between the two products is very unequal. *Gur*-making can be conducted by anyone who has the canes growing, accurate tests regarding ripeness are unnecessary, no capital is required, and the practice can be discontinued at any time. Sugar-making is a new enterprise in India, requires large capital and the difficult combination of many growers, can only be instituted after considerable preparation, and cannot be discontinued without serious financial loss.

(3) *Subdivision of the land.* These difficulties are emphasized by the opinion, general in sugar-making countries, that for commercial success, the enterprise should be carried on on as large a scale as possible. A large block of land is needed, so compact as to reduce the heavy carting charges to a minimum, and the factory should have control over the fields so that it is kept constantly and evenly supplied with the canes. In the settled parts of the country, the holdings are small, and such sugarcane as is grown is in scattered plots of small size. It is impossible to alienate the land for an enterprise of this kind, and it is difficult for any control to be exercised by the factory. This is a very important difficulty and practically rules out large areas in the sugarcane tract from the possibility of sugar-making.

(4) *Competition with other crops.* The whole question of obtaining lands for sugarcane-growing will ultimately depend on the relative profitableness of the crops usually grown. This will be referred to later, but it should be stated here that this rivalry varies with the tract, paddy being a serious rival in the irrigated parts of the Peninsula and in parts of Bengal, jute being the main rival in the sugarcane land of Bengal and cotton in the canal tracts of the Punjab. These crops are not likely to be displaced and the extension of sugarcane in such areas is therefore unlikely.

Summarizing, the extension of sugar-making in India is handicapped by the extremely poor character of the canes grown, by the unequal competition of *gur* where it has a steady and satisfactory market, by the relative cost of initiating *gur* and sugar-making, by the extreme subdivision of the land which renders it impossible to work a factory economically, and by the competition of crops already on the land and

which can be easily and profitably grown. We must turn to places where the price of *gur* is low, where the land is not fully settled, and where it is possible to introduce a better class of cane varieties.

III. Prospects in the different Provinces.

I propose now briefly to pass under review the various tracts in India where sugarcane is grown, in order to emphasize the fact that each has its own peculiar difficulties, and, incidentally, to see in which directions progress is more likely to be effected.

Madras can grow sugarcane as well as any average place in the tropics. It, however, requires irrigation, and thus comes into competition with irrigated crops, mainly paddy. The latter crop is perhaps the easiest to grow in Madras, while sugarcane is one of the most laborious and the most expensive. With present prices of paddy and the possibility of growing more than one crop in the year, it is not likely that sugarcane will to any large extent replace it, even under favourable conditions. Where, however, large quantities of subterranean water are available, paddy competition is ruled out and the matter is less complicated, in that garden crops (those irrigated from wells) also require a good deal of labour. *Ragi* (*Eleusine coracana*), groundnut, and *cholam* (*Andropogon Sorghum*) may be regarded as typical of these. These are the new competitors, and the sugarcane has a better chance, especially as the individual fields are larger. As an example of successful work in sugar-making in such a tract, I would refer to the sugar factory at Nellikuppam in South Arcot. Here, with a better class of cane introduced by the work of the Samalkota Government farm, with large stores of subterranean water and an easily workable soil, sugarcane cultivation has made great strides. By suitable advances, the distribution of manure, and the abundant supply of water by powerful engines, it has been found possible to induce the ryots to grow large fields of sugarcane and bring the canes to the factory. But such areas are rare indeed in Madras, and it has always seemed to me as if a bit of the alluvial plain of the Ganges had been here inserted between the hard red and stiff clay soils of the Peninsula. The tract is, in fact, composed of the alluvium of two rivers, the Gadilam and Ponniar, and is the centre of the groundnut cultivation in India. From what I know of the conditions prevailing in other parts of the Madras Presidency, I do not consider it likely that any great extension of the sugarcane cultivation will take place, and the foundation of many sugar factories appears to be less likely still. I have dealt with Madras rather

fully because it can grow such good thick canes, and this fact is constantly laid hold of by those who wish to extend sugar-making in India.

Mysore. I am not very conversant with the conditions in Mysore, but a good deal of sugarcane is grown there. It is not a paddy country and the population is comparatively sparse. The rainfall is not great and irrigation is necessary. With the extension of irrigation projects or the discovery of subterranean water supplies, it is not inconceivable that sugar factories may be started, but I would defer to the opinion of the Director of Industries, who has, I believe, made a special study of the question.

Bombay. Here the problem is again entirely different. The competition of paddy is removed. Excellent cane crops are raised on the rich volcanic soils, and the juice is very rich in sucrose. Yet the area under sugarcane is insignificant. New irrigation projects are nearing completion in unoccupied tracts, and it is expected that a large part of these will be planted with sugarcane. Whether this is utilized for *gur* or sugar-making will presumably depend on the prices ruling, but it should not be difficult to obtain large compact blocks if the latter is decided on and the capital is available.

The Central Provinces. These are on the line of demarcation between the two great sugarcane tracts in India, and excellent crops of thick canes can be grown in the southern part of the area. The population is sparse, and there is a considerable development taking place in opening up new irrigation works, by which considerable areas will be available for sugarcane-growing. There is indeed reasonable hope that a great deal more sugarcane will be grown in the near future. But the amount grown is at present extremely small, the price of *gur* is very high, and the local Agricultural Department do not consider that sugar manufacture can be undertaken on the new land in competition with *gur*.

Bengal is a great paddy-growing country, but this is chiefly in low-lying land unsuited for sugarcane. The higher land, with sufficient water to do without irrigation, is, however, fully occupied by jute, which has nothing to fear from competition with sugarcane. Good thick canes can be grown in many parts but, in spite of this, the varieties are, on the whole, exceedingly poor and primitive. There is undoubtedly room for considerable improvement here, but the Agricultural Department is under special difficulties in Bengal. The population is very dense, and I do not think it likely that large blocks will be available for sugarcane-growing, even with improved varieties.

Assam. The unique geographical conditions of Assam have already been referred to. The population is very sparse and there are large unoccupied areas in Lower Assam on both sides of the Brahmaputra.

The unhealthiness of the country has, I believe, improved of late years, and there is some likelihood of the increasing masses of Bengal pushing their way into the Assam valley. An experiment on a large scale has been made by Government, to see if these great unoccupied areas can be utilized for the growing of sugarcane. The first stage in this experiment has now been reached, and it is evident that, with certain precautions, thick canes can be grown with great ease over large areas of the grass land in Kamrup. There are special difficulties in the way, such as control of surface water, absence of communications, and scarcity of labour which has to be introduced, but these are to all appearances being successfully overcome, and the prospect is distinctly encouraging. There is a very large amount of land of a nature similar to that on which the farm is placed. The local price of *gur* is, I believe, high, but the demand is not excessive, and it seems more probable that the limiting factor will be the prices ruling in the great Bengal market.

Bihar. The canes in North Bihar are the thin indigenous ones common in North India, although there are some indications that selected thick canes may be grown with advantage. Bihar is, in fact, to some extent a transitional region between the great sugarcane tract in North India and the more tropical area of Bengal and Assam. There are a number of sugarcane factories working, and these, I believe, are, in the main, successful. I am led to think that this success is largely due to the fact that the country is one in which the European planter has worked for many years. He has capital, a crop is needed to replace indigo, the people have long been accustomed to work with him and grow the crops for his factories; he has a certain amount of control over the crops grown and not infrequently a certain amount of land is attached to the factory to form a basis for cultivation. The price of *gur*, although rather high at present, is, I believe, as low as anywhere in India, so that, from the contiguous part of the United Provinces, it is sent as far as the Central Provinces and the Punjab. The pressing need in Bihar is, to my mind, the suitable location of a first class sugar station where varietal and other experiments can be instituted with a suitable staff for combined work with the planters. I am told that the local agriculture leaves much to be desired and the canes certainly need replacing by better varieties.

United Provinces and Punjab. The special conditions in Bihar and Assam are absent further north-west, and the prospects become increasingly less satisfactory. The canes grown are excessively thin and fibrous, the yield per acre is small, and the percentage of sucrose in the juice is often low. This would, furthermore, greatly enlarge the area required for an up-to-date factory, with an increase in the cost

of cartage. The fields are small and scattered and the cultivators are unaccustomed to sell their crops to a central factory. I do not think that there is much prospect of instituting sugar factories in this region, under present conditions.

IV. Work in Progress.

A great deal of work is being carried out on this crop by different Agricultural Departments, but this is scattered and deals with purely local problems. Two experts have been entertained by the Government of India, both of whom are located in provinces and under the local authorities. A Sugar Engineer is engaged in the United Provinces and a Sugarcane Expert in Madras. With the work of the former I am not acquainted, and I propose here only to deal with the latter, in that I consider that the fundamental problem before India is the improvement of the class of canes grown. This is the problem for the solution of which the Cane-breeding Station has been started at Coimbatore. The main line of work is to replace the local North Indian canes by seedling canes, and this, unfortunately, cannot be done in North India because the sugarcane does not flower there. Attempts are being made to obtain new varieties by crossing thin indigenous canes with thick tropical ones, thus combining useful characters of the two classes. Hardy, moderately thin, rich canes are aimed at, which will grow in North India to maturity and be able to withstand the local indifferent treatment at the hands of the ryot. That such an ideal is not unattainable is shown, in the first place, in that crosses have been obtained, although not at present in sufficient quantity or sufficiently studied for distribution, and secondly, because a trial of such a cross has been rendered possible by work in Java. A seedling cane raised there under the No. Java 36 was obtained in Madras and forwarded for trial by the Sugarcane Expert to Shahjahanpur. It was obtained in Java by crossing the local Chunnee of Shahjahanpur with the rich Cheribon of Java. It has been tested now for some years at the Shahjahanpur farm by Mr. Clarke, and the latest accounts have been very favourable, in that last year all the available sets (some nine lakhs in number) were eagerly taken up by the cultivators. Another variety was introduced by the advice of the Sugarcane Expert into the Partabgarh farm, and it has rapidly extended until, in the present year, some hundred acres are under it near that place. These two cases are given as a sample of the work which it is intended to carry out when the new varieties being evolved at Coimbatore are ready for distribution. Altogether some 130,000 cane seedlings have been raised

at the Cane-breeding Station, and it is confidently anticipated that, from among these, and those still being obtained, it will be possible to allocate suitable seedlings for every part of India. It has been estimated that the results of the introduction of new and better canes into Madras some years ago by the Samalkota Sugar Station have culminated in a gain of Rs. 25 per acre, totalling rupees 25 lakhs a year. If the improvement in North India reaches the modest sum of Rs. 5 per acre, it will mean ten crores a year in the ryots' pockets.

It is perhaps needless to point out that if such an improvement can be brought about, the question of sugar-making in India will enter on an entirely new phase. The price of *gur* would be regulated all over the country and possibly considerably reduced by the greater yields obtainable, and there would be a surplus available with more suitable cane varieties for the flotation of sugar-making concerns. But the whole question has its complications, and I do not think that useful results can be obtained with certainty, unless a large view is maintained and the work is properly organized.

V. Founding of a Sugar Department for India.

For this purpose I would suggest the formation of a small Sugar Department for India, to be placed directly under the Agricultural Adviser to the Government of India. I would indicate some of its objects in the following manner, but it is inevitable that the relative importance of the different lines of work would only be clearly understood as progress could be reported :—

(1) The collection into one office of the scattered information recorded regarding the character of the sugarcane tracts in India, the varieties grown, the methods of cultivation and of making the finished product.

(2) The collection of similar information regarding all previous attempts at founding sugar factories, with the reasons for their discontinuation.

Much of this information (under 1 and 2) is now to be found in the files of various Secretariat and other offices in the provinces, but it is not available, and it is desirable to get it together, collate it, and, doubtless in some cases, to publish it in book form or otherwise to serve as a basis for future work.

(3) A continuation of the work on improving the class of canes growing in different parts of the country.

(4) An organized investigation into the local practices of *gur*-making throughout the country, with the object of introducing improvements according to the local conditions.

(5) A special study of the possibility of starting a sugar-making industry in the various tracts where sugarcane is grown.

For such a Department to be effective I would suggest the attachment of the following experts :—

(1) A Sugar factory Expert. He should be thoroughly acquainted with the conditions in India as regards factory work, labour difficulties, general cultivation and the use of by-products. It would be an advantage if he had a working knowledge of the factories and plantations in Java, where the conditions are somewhat similar to those in India.

(2) An Engineer, for the study of existing installations and the preparation of new models and combinations for *gur* and sugar-making.

(3) A Chemist for the study of the cane juice and fibre, to conduct ripening tests and manurial experiments, and to assist in the factory work.

(4) An Agriculturist, whose main duty would be to study the local conditions of soil and climate as affecting the need of irrigation and drainage, the proper times for planting and reaping and the relative period of growth in different tracts.

(5) A Botanist, for the study of the numerous varieties existing, the transference of varieties from place to place and the raising of new seedling canes for each tract.

Such a Department would, at the outset, be largely engaged in collecting material already existing in the country, so as to gain experience as to the proper lines for work. It should therefore be in close touch, consultatively, with the Provincial Departments of Agriculture interested in the crop, and should be prepared to assist and further any work now being carried on by advice or in any other way. Where local effort is considered insufficient it should inaugurate plantations or experiments on its own initiative, but I would specially desire that local efforts should be encouraged, because the officers on the spot will of necessity have the most reliable first hand information as to the conditions and possibilities of their tract. The work at present being conducted on sugar and the sugarcane is scattered and, for the best results to be obtained, I feel sure that it needs to be organized under one hand.

Note on Burma as a Sugarcane Tract.

This province has been visited by the Sugarcane Expert for the first time since the above report was written. I find that there are large areas in Upper, Middle and Lower Burma where thick canes can be quite easily grown. I have only met with one indigenous Indian cane and consider it an introduction, from its botanical character, either from Natal or Bihar. There is any amount of uncultivated land available for the growth of sugarcane, so much so that there is no part of India which can for a moment compare with Burma as a possible place for installation of sugar-making factories. Communications are over large areas quite good, much better, in fact, than I had been led to expect. The population is, however, extremely sparse and labour will have to be introduced. The canes grown, although thick, are generally inferior, and I am at once sending over half a dozen good varieties for their replacement. The local Agricultural Department is wholly insufficient as to numbers and fully employed on useful work, and any steps taken will have to be supported by the Government of India. I would suggest the starting of a small sugarcane station, in each of the five tracts which I have studied, for the acclimatization of better kinds and a study of the best methods of growing the canes. Everything connected with the sugarcane in Burma is on an extremely primitive plane, but in almost every place I visited its cultivation is being extended.

(2)

TRAVANCORE.

(N. Kunjan Pillai, M.A., B.Sc., Ph.D., *Director of Agriculture.*)

I. How to Extend the Area.

Travancore is not a large sugarcane-growing country. Sugarcane is now cultivated only on the lands lying by the sides of some of the rivers, and the total area may not exceed 10,000 acres. But there are facilities for the extension of this cultivation. Some of the wet lands in North Travancore and the low lands lying scattered among the hills on the eastern portion of the country can profitably be brought under sugarcane, and arrangements are being made for extending the crop to these areas. In the north more than 50 persons have started sugarcane cultivation under instructions from the Agricultural Department, and the success that they are meeting with will surely induce many more to follow in their footsteps. In the hilly district also several

persons have of late begun sugarcane cultivation, and this year a joint stock company has got registered 1,000 acres, the major portion of which is going to be put under sugarcane. The increase in the price of sugar brought about by the war is opening the eyes of Travancore people to the profits that await them if they only take to sugarcane cultivation, and as a result of the present activities one can look forward to an appreciable increase in the area under sugarcane in the near future. The Agricultural Department is helping the cultivators by giving them instructions and advice and by supplying them with sets of good varieties of canes.

II. How to Increase the Yield.

The present average yield of *jaggery* in Travancore will hardly be more than two tons per acre. This low yield is due to the defective methods of cultivation, particularly insufficient manuring. The manure that is commonly used for sugarcane, if anything is used at all, is wood ash. The maximum quantity that is applied is not more than 6,000 lb. per acre. A good many cultivators use considerably less than this quantity, while not a few completely dispense with the use of manures. With a view to demonstrate the possibility of increasing the yield of *jaggery* by the use of proper manures the Agricultural Department carried out some experiments during the last two years. The experiments were conducted on one acre plots and the results shown below can therefore be considered reliable.

	Manures	*Quantity applied per acre*	*Yield of jaggery per acre*
1915—1.	Wood ash	6,000 lb.	5,520 lb.
2.	Wood ash	3,000 ,,	7,440 ,,
	Oilcake	1,800 ,,	
	Fish refuse	600 ,,	
1916—1.	Wood ash	6,000 ,,	6,160 ,,
2.	Wood ash	3,000 ,,	7,700 ,,
	Oilcake	1,800 ,,	
	Fish refuse	600 ,,	

The ash used contained about 1·5 per cent. of potash and 0·75 per cent. of phosphoric acid. The oilcake used was that of *Hydnocarpus Wightiana* and contained 1·5 per cent. of potash, 1·2 per cent. of phosphoric acid and 4 per cent. of nitrogen, and fish refuse contained 5 per cent. of nitrogen and 4 per cent. of phosphoric acid. Thus the ash plot received about 90 lb. of potash and 45 lb. of phosphoric acid, while the other plot received 92 lb. of potash, 67 lb. of phosphoric acid and 102 lb. of nitrogen. It may probably be necessary to vary

the composition of the mixture which can only be done after further experiments. The two experiments described prove clearly the advantages of the mixture over ash. The increase in the yield of *jaggery* was in the one case 1,920 lb. and in the other 1,540 lb., or on an average 1,730 lb. At the present market price of *jaggery* the value of 1,730 lb. is about Rs. 150, and the difference in the price of the manures used was only Rs. 25, the mixture costing Rs. 55 and ash Rs. 30.

It is clear from what has been stated above that by the use of proper manures an acre of sugarcane will yield 3 to $3\frac{1}{2}$ tons of *jaggery*. The average yield at present in Travancore, as already stated, is not more than 2 tons per acre. If all the existing 10,000 acres are cultivated with proper manures the total out-turn of *jaggery* can be increased from 20,000 tons to nearly 35,000 tons. The Agricultural Department is doing all it can to induce the sugarcane cultivators to use the manure mixture which has produced such striking results. The Department has opened this year a manure depôt in an important sugarcane area, and the cultivators in the neighbourhood have purchased manures for nearly Rs. 1,000 in the course of 2 or 3 months. There would have been a much larger sale if arrangements had been made to sell manures on credit and to realize the price during harvest time. If such a system is introduced and manure depôts are opened in other sugarcane areas also, it is possible to make manures widely popular among sugarcane cultivators and thereby bring about a substantial increase in the out-turn of *jaggery* in the country.

11th August, 1917.

(3)

MYSORE.

(L. C. Coleman, M.A., Ph.D., *Director of Agriculture.*)

I. Experimental Work.

(*a*) *Testing varieties.* The results of the past three years have shown conclusively that Red Mauritius cane is a higher yielding variety than any of our local canes. This has been corroborated by nearly all the demonstrations held on private lands. Careful tests on the Hebbal farm indicate that we may anticipate an increase of yield of from 15 to 20 per cent. by the introduction of this variety.

(*b*) *Manurial tests.* The results of manurial experiments with different quantities of local oilcakes indicate that doses up to two tons of castor cake per acre are very profitable at present prices.

(*c*) *Spacing tests.* Experiments have shown that the present planting distance for sugarcane (rows 1 ft. to $1\frac{1}{2}$ ft. apart) is too close and that yields at least as good can be obtained by planting twice the distance apart. This is of particular importance in the rapid introduction of new varieties.

(*d*) *Work on seedling canes.* A large number of seedling canes have been tested and some of these are giving distinct promise. The most promising seedlings are those of White Mauritius, Striped Mauritius, and Red Mauritius. Seedlings are being selected for vigour, purity of juice, and high sucrose content. The weakness of Red Mauritius is the impurity of its juice and its comparatively low sucrose content; its strength is its great vigour. Some of the seedlings obtained from it promise to be just as vigorous as the parent and to yield a very much richer and purer juice.

II. Establishment of New Farms.

Two new experimental farms which will be devoted largely to sugarcane cultivation have been established within the past two years. One of these is situated under the Marikanave Reservoir where there is an area of about 20,000 acres, 10,000 of which could be devoted profitably to cane. The soil is rather poor and distinctly alkaline, and the work of this farm will have to do with the best means of improving the soil and preventing the increase of alkalinity. The other farm is situated under the new Kannambadi Reservoir where it is anticipated that we shall be able to increase our sugarcane area by 30,000 acres annually. Here the function of the farm will be largely the testing of varieties, the supply of seed, and the demonstration of improved methods of manuring and cultivation. On the former of these farms a power mill is being installed.

III. Demonstration Work.

(*a*) *Introduction of new varieties.* This work has, up to the present, been practically confined to Red Mauritius and an unnamed Java cane. We have been distributing cane in small lots from our central farm for several years, but it has been found that this is an extremely wasteful method as a great many of the sets become damaged in transit. A somewhat novel scheme is therefore being developed for the establishment of a large number of supply centres. Sugarcane sets are supplied

from our farms and are delivered to sugarcane-growers free of charge on the understanding that double the number of sets are returned the following year. These are then distributed under the same conditions the following year. By this method a large number of supply centres are being established and a very rapid introduction of improved varieties will result. As soon as tests on our farms reveal other varieties of outstanding merit they will be distributed in the same way.

(*d*) *Popularization of the use of oilcakes as manures for sugarcane.* While the best sugarcane-growing districts of the State use oilcakes in large quantities as a manure for cane, in over half our area the use of oilcakes was practically unknown till the Department took up the work of popularizing their use three years ago. The scheme followed is an interesting one. Large quantities of oilcake (about 100 tons) were purchased by the Department and were given out in lots sufficient for one or two acres in areas where the use of oilcake was rare or unknown. Those receiving the cake agreed to pay the cost at the end of their harvest season when the results of the manuring could be seen. The results were almost without exception favourable and the demand for manure increased. During the first two years the manure was advanced without interest, but during the present year interest at 6 per cent. is being charged. As the price of local cakes had increased greatly and as furthermore they were being taken up by local sugarcane-growers, the Department got into touch with oil-pressers outside the State in Bombay and Madras Presidencies with the result that we have been able to obtain our supplies at a much lower rate and at the same time have not in any way disturbed the local supplies. During the past year about 300 tons of groundnut and safflower cake, two cakes which have been practically unknown to Mysore sugarcane-growers and which are much richer than our local cakes, have been distributed. A scheme is being developed for the crushing of the large supplies of oil-seeds (chiefly castor and groundnut) which are now being shipped out of the State. It is proposed to erect a large oil-seed-crushing plant under the control of the Department of Industries and Commerce, the Department of Agriculture to take over the distribution and sale of the cake in new areas. The scheme contemplates the production of between 1,000 and 2,000 tons of cake per annum. If the scheme is successful similar plants are certain to be established by private agency, and it may perhaps not be too sanguine to anticipate that within the next ten years we shall find the bulk of the oil-seeds which are now being exported utilized in the State.

October, 1917.

(4)

BOMBAY.

(*a*)

(J. B. KNIGHT, M.Sc., B.Sc., *Professor of Agriculture, Poona.*)

I. AGRICULTURAL ASPECT.

Most of the work with cane has been along the lines already put before the Board in the year 1916, by Rao Bahadur G. K. Kelkar, the then acting Professor of Agriculture.[1]

Manjri farm was the first centre for experimentation and demonstration of better methods with this crop. Later work was undertaken in Satara and Nasik. The use of concentrates and better furnaces being the main lines, district work has steadily spread and now includes all the cane-growing tracts. In the district, besides demonstrating the results of Manjri, special problems of local importance have been taken up. The principal centres of this work are Kasundra, Ahmedabad District, where improvement in *gur* manufacture and white-ant attack were the problems. Here the Manjri methods of *gur* manufacture have been successfully introduced. At Amalsad, Surat District, the question was of red-rot. At Kopergaon the work has taken the line of introducing improved methods of cultivation and manufacture, also the best way to deal with this crop on peculiar types of soil. In Nasik the improvement in manufacturing methods has been steadily pushed. The old type of furnace is nearly extinct. Crushing is being improved by means of establishing co-operative power crushing plants. In Satara, Belgaum and Dharwar, the improved furnaces are increasing. In Nira and Mutha valleys, near Sholapur, in small areas in Belgaum, Dharwar and Satara, the spreading of the new Manjri method as outlined in Rao Bahadur Kelkar's note referred to above has proceeded. In the districts of Nasik, Ahmednagar, Satara and Belgaum, sulphate of ammonia has been found very useful as a cane manure and its use is rapidly spreading.

Iron mills have now become practically universal. The Nahan, Alcock and Chattanooga No. 33 are the new types that are giving satisfaction and gaining popularity. The Alcock was devised in consultation with the Manjri farm staff.

Two hundred lots of canes from Bombay cane-growing tracts have been brought together at the Manjri farm. The seed has been

[1] *Proceedings of the Board of Agriculture in India, 1916*, p. 94.

increased and those which are obviously of the same variety have been grouped together. Analyses have been made and sub-groups established on the composition basis. Manner of growth, earliness, etc., have been noted. The special adaptation of each group as to soil, climate, and methods of cultivation, is being studied. About sixty varieties from other provinces and outside India have been obtained and grown at Manjri. Five varieties have been grown on a scale for obtaining yield figures. These appear to be useful for tracts where the growing season is short on account of their earliness. These are known at the farm as Red Sports, Striped Mauritius, and J. 36 M. These are nearly equal to Pundia, in yield and richness. Two other varieties, Green and Red Mauritius, are proving useful as 18 months crops.

II. Cultivation.

Several methods of growing cane are under experimentation, including Java, West Indies, Mauritius, modified Java, modified West Indies, and Manjri farm methods; results are yet to come. Seed rate and tillering are also under study. It is certain that a lower seed rate is practical.

Observations of cane fields at different places under ordinary and careful methods show that a number of the tillers sprouting from sets do not form mature canes at all or form only very small ones. With a large number of sets, *viz.*, from twelve to eighteen thousand, having three or four eyebuds in each and a large number of tillers from each, the present yield of cane is only about 25,000 in number weighing about 80,000 lb. To avoid this waste Rao Saheb Kulkarni, Acting Deputy Director of Agriculture, Southern Division, is experimenting with single eyebud plants, and his standing crop is very promising. The question of transplanting of young plants from one eyebud is also being investigated by him.

III. Manure.

San (*Crotalaria juncea*) as a green manure has been demonstrated to be the most economical coarse manure. On the Kopergaon canals a method of growing the *san* with the crop and burying at earthing up, is gaining ground. Stable manure has proved superior to farmyard manure.

September, 1917.

(*b*)

(The Hon'ble Mr. G. F. Keatinge, C.I.E., I.C.S., *Director of Agriculture, Bombay.*)

* * * *

Sugar.

To the extent of its irrigation facilities the Deccan has admirable facilities for sugar production. At present these irrigation facilities are very limited, and the sugarcane crop grown on the water allotted to it is worked up into *gur* or raw sugar consisting of all the solid contents of the cane juice. Some cultivators grow excellent cane, and the industry so far as it goes is a profitable one, but the average production of cane is much lower than it should be, and the losses that occur in the manufacture of *gur* by primitive methods are large. It has now been decided steadily to increase the area under canal irrigation in the Deccan, and a large programme has been drawn up. The following canals will increase the area under sugarcane by about the acreage mentioned against them, *viz.*, Godavari canals (just completed), 12,000 acres; Pravara canals (almost ready), 12,000 acres; Nira Right Bank canal (under construction), 20,000 acres; and Gokak canal (sanctioned), 20,000 acres. Total 64,000 acres. There are many other canals to follow. As these new canals are opened, and as cane growing increases it is probable that if all the produce is made into *gur* there will be a glut of *gur* for local consumption and possibly a disastrous fall in price. The manufacture of sugar will then become necessary. In order that sugar factories may be started they must be able effectively to control a certain area of land on which they can grow a large part of their own cane, and this area must be compact, so as to allow cheap and rapid transport of cane to the factory. This involves the crux of the situation, since the land is at present occupied in small lots by the very large number of landholders, and it is not possible for a projected company to obtain a large block of land on a secure tenure. I believe that there is only one way in which this difficulty can be overcome without injustice to the present occupants, and this would involve legislation. The plan would be this. When the alignment of a new canal is settled and it is decided to allot perennial water to a definite area (say 20,000 acres), the area to which perennial irrigation can be best applied should be settled by a survey. The holdings in this area should then be pooled and squared, each cultivator receiving (say) three-fourths of the area which he held before, with water rights attached, and the remaining one-fourth should be retained

by Government for assignment preferably on a long lease, to a sugar company. This area would be in one block and would enable a sugar company to get to work under optimum conditions. A cultivator who formerly had 20 acres of dry crop land in a region of precarious rainfall would now have 15 acres with water rights attached, and would be in a much better position than he was before. In this way a profitable sugar industry might be created and the future of the Deccan canals assured. Incidentally the arrangement would greatly improve irrigation practices, check damage to the land from over-irrigation and enable the land under the canal to be developed in an orderly and businesslike fashion, to the great advantage of the cultivators and the public.*

(5)

CENTRAL PROVINCES.

(D. Clouston, M.A., B.Sc., *Officiating Director of Agriculture.*)

All the cane grown in the Central Provinces is used either for chewing or for *gur*-making. The varieties in demand for chewing are thick soft canes like Pounda and Ashy Mauritius. Mr. McGlashan, who started cane cultivation in the Chanda District some years ago with the view of establishing a factory for the manufacture of white sugar, has not yet been able to make a beginning, owing to the difficulty of procuring machinery from home.

A large number of improved cane mills have been introduced in the provinces within the last 10 years. In Chanda District alone, over 300 Sultan mills, costing at present Rs. 140 each, have been sold by the Department. Considerable progress has also been made in introducing the improved furnace for *gur*-making. The cost of manufacturing *gur* by this—the Poona furnace—is thereby being reduced very considerably, as it is no longer necessary to purchase wood for fuel. Owing to the difficulty experienced in finding sufficient draught power to crush any considerable quantity of cane on an average holding, cane-growers are loth to increase their cane areas to any great extent. The introduction of small power cane mills, capable of crushing from 5 to 10 tons per day, would appear to be the most practical way of solving the difficulty. The Department has two such plants on the Sindewahi farm, one of which is being hired out to cane-growers in the neighbourhood.

Much attention has been given to the study of indigenous and exotic canes both from an agricultural and a chemical aspect. Of the numerous varieties which have been tested within the last 10 years,

* Extract from the Evidence given before the Indian Industrial Commission.

the best results have been obtained up to date from Sunnabille, Khari, Java 247, Yuba, Ashy Mauritius, and Red Mauritius, all of which have been introduced by the Department. Sunnabille, obtained 10 years ago from Bombay, has in parts of the Southern Circle largely ousted the thin reed-like local cane known as Katai. Khari and Java 247 are also being grown very successfully. The former has now been under trial as a ratoon crop on the Telinkheri farm for 7 years. As a ratooner it is second to none. This particular variety, tried for the first time on the Telinkheri farm 8 years ago, has since been grown most successfully both in the Northern and Southern Circles. Like Java 247, Sunnabille and Yuba, it does equally well on heavy black clayey loams and on the thin lateritic soil of the *bhata* plains of Chhattisgarh. Of the thick canes under trial Ashy Mauritius is perhaps the most promising. Seed of this variety has been supplied to cultivators in considerable quantities. Java 247 is the hardest of all the varieties tried, and for that reason we recommend it as a cane suitable for villages where wild pigs damage the softer canes. It is evident from the experiments carried out by the Department that under the conditions prevailing in the average village, the cultivation of canes like Java 247, Sunnabille, and Khari pays much better than that of the thicker and softer varieties. Efforts are therefore being made to extend the cultivation of these harder and hardier canes. Over 4 lakhs of canes of the three varieties named above were supplied to cultivators last year for seed purposes.

Experiments to ascertain the best method of cultivating cane have shown that whereas the trench or Java method gives as a rule the larger out-turns, it requires at the same time much more labour for the digging of the trenches by hand, and labour is difficult to procure in most districts during the planting season. The furrow system, by which the land is ridged by means of a furrow plough drawn by a pair of bullocks, is much cheaper and more expeditious than the Java system. The Delta plough is being used on Government farms not only for making the furrows but also for earthing up the cane later. By using this plough and the Planet Junior hoe for cultivating cane the cost is much reduced.

Irrigation and manurial experiments are being carried out on black clayey loam, on lighter sandy loams, and on gravelly lateritic soils. The manuring of cane with cattle-dung or *san* hemp, followed by a top-dressing of cake, has been found to be the most profitable system for adoption on a large scale, though sheep-folding pays better where sheep are available. From results already obtained from experiments lately started on some of the Government farms, it would appear that our soils are deficient not only in nitrogen but also in phosphates, and that

the application of superphosphate adds largely to the acreage out-turn of cane. The manuring of cane with *san* hemp has been adopted as a regular practice on some of the Government farms, and a few cultivators have already begun to follow our example.

The production of refined sugar is not a question of any practical importance in the Central Provinces at the present time. The attempt made 8 years ago to manufacture white sugar by the Hadi process proved a failure. The Department, however, is devoting much attention to ways and means of improving the quality of *gur*. That produced on Government farms is sold locally at $4\frac{1}{2}$ to 6 seers per rupee when the price of the United Provinces *gur* in the bazaar is 8 seers per rupee. The area under cane in the Central Provinces has declined very much within the last 20 years owing to various causes, the chief of which have been the cost of irrigation, the cost of fuel, and the difficulty of protecting the crop from wild pig. An extension of the area under cane may be expected under the larger Government irrigation works, more especially under the Mahanadi and Tendula canals which are now nearing completion in Chhattisgarh. Under these canals there are very large stretches of waste land known as *bhata*, a lateritic soil which has been found on the Chandkhuri farm to be specially suitable for cane-growing.

The improved furnace which the Department is getting cane-growers to use meets the fuel difficulty. To get rid of wild pig, pig-killing clubs have been formed in some parts of the provinces, while in other parts the crop is being fenced with patent pig-proof fencing which the Department of Agriculture keeps in stock at some of its implement depôts.

August, 1917.

(6)

BENGAL.

(R. S. Finlow, B.Sc., F.I.C., F.C.S., *Officiating Agricultural Chemist.*)

I. Experiments at Dacca.

(*a*) *Investigation into local canes.* In the last report on sugarcane in Bengal written in 1916, the commencement at Dacca of the work of classifying the local sugarcanes of Bengal was described.[1]

This work has been carried on since Mr. Annett's departure. Weather conditions in the season 1916-17 and also in 1917-18 have been very unfortunate as far as the red soil of the Dacca farm is concerned; nevertheless considerable progress has been made.

[1] *Proceedings of the Board of Agriculture in India, 1916*, p. 89.

Briefly, the object has been to grow the local canes side by side with the best exotic varieties and to compare the respective varieties both as regards their yields of cane per acre and also the sucrose content of the cane juice.

It was mentioned in the last progress report that there was some uncertainty regarding the identity of the varieties sent in from the district and, on the advice of Dr. Barber, who inspected the plots in the cold weather of 1915-16, a new set of specimens was arranged for. These were planted in Mastul field in 1916.

The varieties were distributed as follows :—

From—	
Dacca District	13
Pabna	1
Mymensingh	9
Burdwan	6
24-Parganas	1
Rajshahi	2
Backerganj	3
Faridpur	5
Chittagong	3
Murshidabad	1

In addition, there was one cane each from the United Provinces and the Central Provinces respectively, besides five Bengal varieties of which the origin is uncertain. There were also 9 exotic canes.

All these varieties were grown at Dacca in 1916-17 and 1917-18. There were obviously too many to allow of a sufficient area of each to be planted to enable a *gur*-making test to be made, and selection has therefore been based on analytical figures and on personal inspection of each variety. Fourteen varieties have been provisionally selected in this way for more detailed investigation.

Where sufficient sets are available the selected canes will be tested in the present season for their yield of *gur* as well as in regard to their purity of juice and yield of cane per acre. In several cases, however, further multiplication will be necessary before this can be done.

In selecting the canes, the very different conditions which exist in various parts of the province of Bengal have to be borne in mind. For instance, Rajshahi is somewhat similar to Bihar but with a better rainfall. In Faridpur and in several other tracts the sugarcane crop has to exist for a considerable portion of its period of growth in land which, excepting in the first month or two, is probably always water-logged, and very often inundated to a depth of one or even two feet. In the red soil tracts of Dacca and Mymensingh, on the other hand, the crop has to withstand almost arid conditions in the latter portion of the season.

It is conceivable therefore that a cane which will suit one tract in the province may not do for another, and until this point is settled it will be necessary to retain the best types of cane grown in the respective tracts.

(*b*) *Exotic varieties.* Of these, Yellow Tanna and J. 247 are the canes which seem to withstand the conditions at Dacca best: but it must not be forgotten that the last two seasons have been entirely unfavourable. This has been chiefly due to prolonged droughts in the early part of each season: thus only the most vigorous canes were able to establish themselves. Dacca Gandari, which with 4,240 lb. of *gur* per acre was practically equal to J. 247 in 1916-17, did not improve in 1918, whereas J. 247 yielded 6,000 lb. of *gur* per acre on duplicate plots.

In another year, like the present, 1918-19, which has been decidedly favourable so far, the more delicate races may well come to the front. When B. 147 and B. 208 were first introduced into Dacca by Mr. Meggitt, yields approximating to 120 maunds of *gur* per acre were obtained. But, however well a race may do in good years, it is a very great disadvantage if it is unable to withstand adverse conditions, and it is a matter for discussion whether the Department should ever attempt to introduce the cultivation of such a cane on a large scale. This is especially the case if another race is at hand which is hardy, even if its yielding capacfty is not quite so great. Looked at in this way, a bad year is often by no means wholly unfortunate from the point of view of the investigator.

During the last two or three years there has been a good deal of disease at Dacca and, at the commencement of the present season, it was decided to select rigidly the canes which were to be used as sets. Each of these canes was examined and passed by the Entomological and Mycological Collectors, and it is probable that the greatly improved appearance of the cane this year is due partly to the care thus exercised, as well as to a favourable season. The selection will be systematically pursued each year in future.

II. Sugarcane Experiments at other Stations in Bengal.

(*a*) *Rangpur.* The following races have been grown at the Rangpur Dairy Farm in the last two years:—

Variety	Yields of *gur* per acre	
	1916-17	1917-18
	lb.	lb.
Yellow Tanna	4,600	4,620
Vendamukhi (Rajshahi)	2,760	3,299
B. 147	4,400	4,440
Samsara (Burdwan)	1,500	2,824
Striped Tanna	2,950	4,520
Dacca Gandari	5,400	5,720
Khagri (Local)	..	2,820

Thus at Rangpur, though none of the returns are very high, Dacca Gandari has proved the most satisfactory yielder in both years, Yellow Tanna being second best in both years.

At the Rangpur Demonstration Farm, Dacca Gandari, with 67 maunds of *gur* per acre, was the best yielder in 1916-17, while in 1917-18 Gandari, B. 3412 and Red Mauritius were all close together with 5,120, 5,480 and 4,800 lb. per acre respectively.

It is proposed to introduce J. 247 into Rangpur in the next season, 1919-20.

(*b*) *Chinsurah.* The season 1916-17 was an unfavourable one, partly on account of drought, and partly because of a heavy cyclone in September 1917, which did considerable damage. Nevertheless some of the canes did well.

In 1917-18 the crop was a good one and some very high yields of *gur* were recorded.

Variety	Average outturn of *gur* per acre	
	1916-17	1917-18
	lb.	lb.
Yellow Tanna	8,241	8,400
B. 147	6,052	7,520
B. 208	4,067	5,304
Red Mauritius	6,244	9,160
B. 3412	5,976	8,320
Striped Tanna	4,006	9,920
Samsara (Burdwan)	3,892	8,198
Dacca Gandari	3,436	6,518
Puri (Burdwan)	3,104	..
Vendamukhi (Rajshahi)	..	7,148
Khari (Burdwan)	..	7,365

Yellow Tanna stands first on the average; but Dacca Gandari is apparently not so much at home at Chinsurah as at Dacca and Rangpur. On the whole the more favourable conditions at Chinsurah are reflected, as at Rangpur, in considerably higher yields from the more delicate varieties.

(*c*) *Rajshahi.* The following varieties have been grown at Rajshahi in 1915-16, 1916-17, and 1917-18. The results for 1916-17 are not given. Moisture was very poor in that year and germination of the sets was so bad as to make the results unreliable :—

Variety	Weight of *gur* per acre			Remarks applying to the 1917-18 crop.
	1915-16	1916-17	1917-18	
	lb.		lb.	
Vendamukhi (Local) .	9,030	..	8,540	Lodged.
Puri (Local) . . .	6,460	..	..	
Striped Tanna .	8,870	..	10,606	Stood erect.
Yellow Tanna . .	8,860	..	11,352	Do.
B. 147 . . .	8,330	..	7,960	Blown down.
Dacca Gandari .	..	..	4,196	Blown down and greater portion damaged by wild animals.

As at Chinsurah the Tanna varieties gave the best yield in 1917. This was probably partly due to their sturdy capacity for withstanding rough weather and partly to their being able to resist attack from jackal and pigs. This latter is a particularly valuable property in a district like Rajshahi where wild animals generally are more than usually common.

III. General Remarks.

The conclusions to be drawn from the experiments recorded above are that at three out of four experiment stations in Bengal, an exotic race generally leads the way in the matter of yield as compared with local varieties.

On the other hand, at Dacca, Chinsurah and Rangpur, there are local canes, namely, Gandari, Samsara, and Vendamukhi respectively, which if not equal to the best exotic are still capable of profitable cultivation.

It would appear that in most cases exotic canes are not capable of retaining their good qualities indefinitely ; but as far as Bengal is concerned Yellow Tanna seems to be an exception. It has been grown in the province for many years now, and while still on the average one of the best, if not actually the best, *gur*-making canes it is also probably the most robust variety. Noel Deerr states (" Cane Sugar ", page 29) that " generally speaking they (Tanna varieties) are deep rooters and suffer only to a limited extent from the effects of drought." This might

have been written from experience with Yellow Tanna on the red soils at Dacca.

A second cane has shown great vigour at Dacca in the last two years. This is J. 247 which, while tillering freely, and growing to a great height, appears to resemble Yellow Tanna in its drought-resisting properties. Sufficient sets of J. 247 will be available next season for extended tests at each of the four experimental stations in the province.

Both Yellow Tanna and J. 247 appear to be canes whose juice is only of moderate purity. Therefore, while excellent as far as *gur*-making is concerned, they might be at a disadvantage as compared with some other canes when white sugar is the object.

27th May, 1918.

(7)

BIHAR AND ORISSA.

(G. Milne, I.C.S., *Director of Agriculture.*)

The scheme for the establishment of a sugarcane station in North Bihar, which had been approved by Government but postponed on account of the financial stringency and also of the difficulty of getting factory *zirats* owing to the revival of the indigo industry, was subjected to further examination in the light of the recommendations of the last Board of Agriculture. A site has been provisionally selected in the district of Darbhanga and, if it proves to be satisfactory on further inspection during the rains, a detailed scheme for the establishment of the station will be submitted to Government.

In the meantime some work is being done at Sipaya and Sabour.

On the Sipaya farm sixty varieties of sugarcane, of which 54 were obtained from various quarters of the province and 6 from Queensland, Australia, have been under cultivation, the area at present occupied by the former being 5·10 acres and by the latter 2·18 acres. All the varieties except one have been analysed for sugar content under the direction of Mr. C. S. Taylor, Agricultural Chemist to Government, and a record has been kept of the analysis made.

On the Sabour farm the work has been limited to the best method of growing the cane, and it has been proved that the trenching method generally adopted in Mauritius is suitable to the conditions of Bihar, as it provides for irrigation and for draining the surface water of the land in the rainy season.

On the mechanical side, Banerji's sugarcane-crushing mills and iron evaporating pans for *gur*-boiling have been found to be superior to local ones and are being recommended to the cultivators.

On the botanical side, the varieties of sugarcane isolated at Sabour by selection have been cultivated in pure culture.

The Mungo variety of sugarcane and the ridge and furrow system of cultivating it have been extended in parts of Cuttack and Puri districts. The improved method of *gur*-making by the shallow evaporating pan has also been introduced in these and other areas ; the *gur* thus manufactured from the Mungo variety fetched Rs. 2 more per maund ($82\frac{2}{7}$ lb.) than the *gur* made by the local method.

September, 1917.

(8)

UNITED PROVINCES.

(The Hon'ble Mr. H. R. C. Hailey, C.I.E., I.C.S., *Director, Department of Land Records and Agriculture.*)

As this is the last year in which Mr. Hulme will have an opportunity of attending the Board of Agriculture, he has put up a full note on the working of the experimental factory at Nawabganj and enclosed illustrations of the plant employed.[1] At the last meeting of the Board it was suggested that arrangements should be made for a more adequate supply of cane to the factory. Mainly owing to the extremely bad crop in the neighbourhood, this was impossible last season, but advances have been given this year to cultivators, which should, provided the crop is a normal one, secure a future supply. As regards the question of the progress made since the last meeting, it must be pointed out that since that date it has been practically impossible to obtain sugar-making machinery of any description, and therefore any development on the manufacturing side has been out of question. In addition to this, the price of *gur* has risen considerably and there has been a greater tendency to look to *gur*-making than to sugar as a profitable business. It may, however, be mentioned that the two sugar factories in these provinces that have in different ways received assistance from Government, namely, those at Pilibhit and Tamkohi, are now in full working order and it is understood that they had successful seasons. The latter last season turned out

[1] *Pusa Agri. Res. Inst. Bull.* no. 82.

close on 3,000 tons of sugar. As to future developments on the manufacturing side, some of the larger growers in these provinces, particularly owners of private farms, are contemplating putting down *gur*-making factories as soon as plant is available, and a number of communications have been received regarding their instalment. It is clear that the absolute necessity for using mechanical power for crushing, if cane is grown on at all a large scale, is now more fully realized, and it is believed that there will be a good demand for power crushing plant as soon as the machinery is available. Assistance was given by the Agricultural Adviser in demonstrating a small power crushing plant, and a certain number of mills made in the country or imported from America are in use. It is probable, however, that though suitable for cultivators working with oil engines, a larger type will be required for *gur* factories.

On the cultural side the work at the research farm has been continued on the lines previously indicated. Attention had mainly been devoted to putting out some of the varieties found most suitable at the Shahjahanpur station and to improving methods of cultivation generally by demonstration work. A considerable number of demonstrations have been given and opportunity has been taken to distribute gratis cake manures with a view to their popularization. The Department in this respect has received considerable assistance from the cane factories at Rosa and Tamkohi and from the owners of private farms who have begun the cultivation of cane on a large scale. Some of these private farms have followed the methods of cultivation recommended by Mr. Clarke with considerable success and have effected marked improvement in yields of *gur*. The main work of the Department is concentrated on teaching the people better methods of planting and cultivation, and it is believed that when these are more generally in force the introduction of better classes of cane will necessarily follow ; but, until adopted, the best results will not be obtained from the work at the research farm in these provinces or that at Coimbatore.

October, 1917.

(9)

PUNJAB.

(C. A. H. Townsend, I.C.S., *Director of Agriculture and Industries.*)

The late Mr. Barnes wrote three progress reports on sugar in the Punjab. The reports for 1911-12 and 1912-13 have been printed :

the third, which covers the progress made after 1913, is in the press, under the supervision of the Agricultural Adviser to the Government of India.[1] A perusal of these reports will show that the survey and analysis of the principal canes grown in the Gurdaspur District and on the experimental farm there has been completed. The experimental and varietal testing of canes on the farm, commenced in 1912, is still in progress. No cultural experiments have as yet been instituted : manurial experiments with artificial manures have recently been commenced.

The results arrived at so far are as follows:—

The Punjab as a whole is ill-suited, on account of its cold winter, to canes, and the crop can never become really popular in the province. A proposal to start a small sugarcane farm in the Karnal or Gurgaon District, in the south-east of the province, where the climatic conditions are much more suited to cane than the more northerly parts of the province, and where the yields per acre are very much greater, is under consideration.

As to varietal tests, a commencement was made in 1912 with some 40 varieties, both indigenous and exotic, thick and thin. All these came from India : to them were added in 1915 an Egyptian cane, J. 105, brought by Mr. Barnes himself from Egypt, and J. 33, a Java cane.

Nearly all the thick varieties have been discarded ; a few of the more promising ones are still under trial, and will be transferred to the new station in the south-east of the province, if and when it is formed. J. 105 and J. 33 have done fairly well on the farm, and are expected to do well in the Karnal District where they have been given for trial this year. These are medium thick canes.

Of the thinner varieties some twelve are still under trial at the Gurdaspur farm : five of these—Sonabli, Behar, Suretha, Mungo and Dhaura of Azamgarh—have given almost always good results. They were given out to zemindars last year in the Gurdaspur District, and were well reported on. They are being again grown this year : of these Behar and Sonabli appear the best.

Yuba is another cane recently obtained from the United Provinces, and still under trial. It is giving promising results.

Mungo and Dhaura of Azamgarh are well suited to low-lying *bet* (riverain) lands : the latter gave as much as 60 maunds of *gur* per acre. This was grown without any artificial irrigation.

Some sugarcane work, both varietal and manurial, is also being conducted at Lyallpur and Hansi : but it is not, as yet, very important.

August, 1917.

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1 "Sugar and the Sugarcane in the Gurdaspur District." *Pusa Agri. Res. Inst. Bull.* no. 69.

(10)

NORTH-WEST FRONTIER PROVINCE.

(W. Robertson Brown, *Agricultural Officer.*)

I. Sugarcane.

Climate of the Peshawar valley. It is sometimes stated that the Punjab and the North-West Frontier Province are outside India's sugarcane belt. To understand, therefore, how on 25,000 acres of land such a high weight per acre of cane, fairly good in quality, is annually produced at Peshawar, it is necessary to know something of the climate and environment of that part of the valley where most of the cane is grown. Four seasons are recognized at Peshawar.

Spring in February, March, and April. During the earlier part of this period there are occasional light hail-storms, and usually rain falls to the extent of three or four inches. Cane is planted about the 15th March. Normals of temperature derived from the data of 33 years are as follow :—

Month	Normal maximum temperature	Normal minimum temperature	Normal mean temperature
February	65·7	42·5	54·1
March	75·0	51·7	63·3
April	85·5	60·3	72·9

Summer comes in May, June and July. Rain rarely falls during this season, which is the hottest of the year. It is frequently dense hazy, and dust storms occur in June and July. In this season the young cane plants become established. Normals of temperature derived from the data of 33 years are as follow :—

Month	Normal maximum temperature	Normal minimum temperature	Normal mean temperature
May	98·1	69·9	84·0
June	105·9	77·3	91·6
July	102·7	79·2	90·9

Autumn comes in August, September and October. The season is ushered in by the hot weather rains. They break over the valley in four or five violent storms at intervals of a few days, and two or three inches of rain fall on each occasion. During the first part of this season the sky is more or less uniformly overcast with clouds, and the air is steamy and oppressive. The growth of the cane is extraordinarily rapid during this season. Normals of temperature derived from the data of 33 years are as follow :—

Month	Normal maximum temperature	Normal minimum temperature	Normal mean temperature
August	99·2	78·0	88·6
September	95·6	70·5	83·1
October	88·2	57·9	73·1

Winter comes in November, December and January. During this season the weather is variable. The sky is at first hazy, then cloudy, with sometimes slight rain. There is a remarkable absence of wind generally and the air is still and stagnant. The first touch of frost is expected towards the end of November, and the sugarcane then ceases to grow. Normals of temperature derived from the data of 33 years are as follow :—

Month	Normal maximum temperature	Normal minimum temperature	Normal mean temperature
November	77·3	46·1	61·7
December	67·0	39·2	53·1
January	63·0	39·6	51·3

The plant-cane is fully established and well away by the 15th June ; in July the crop is earthed up ; in August, September, and October the cane lengthens and gains in weight very rapidly (owing to its exceedingly rapid growth, the Peshawar cane has very long internodes and, in consequence, exceptionally high juice percentage). In November the cane begins to ripen and with the first touch of frost the cultivators start cutting the crop.

Cultivation. The method of growing cane in Peshawar District is probably unique in the production of the crop, and it is certainly one of

the cheapest and most efficient practised anywhere. On the 15th September a clover (*Trifolium resupinatum*) is broadcasted over the level land. The resultant crop is cut for stock in November, again in January, and in early March. Then the area is lightly furrowed or marked by the country plough at intervals of about three feet and the sugarcane sets are laid end to end in these shallow drills without any covering of soil. The area is next irrigated. In a few days' time the clover grows up and covers the cane sets, and these quickly put forth roots and send out shoots through the clover. In April the clover is again cut and laid alongside the growing cane, there to rot and enrich the soil. In May the lines of cane are lightly hoed, some manure is applied to the plants, and the lines are inter-cultivated by the country plough. Later cultivation consists of weeding, inter-tillage, and irrigation until late July, when the lengthening cane is substantially earthed up. After this nothing further but generous irrigation is given till the crop ripens in December. No tying-up or protection from jackal or pig is necessary at Peshawar. After many trials of other better known methods of cultivation, no practice has been found so simple, so cheap and efficient as that which the Peshawar growers have followed for a quarter of a century.

Cost of cultivation. Under the method described in the preceding paragraph, crops of from 25 to 30 tons of cane per acre are usually produced by the cultivators at a cost of Rs. 4 to Rs. 5 per ton. This price includes rent, revenue, and all other charges. After many trials and experiments the Peshawar Agricultural Station has not succeeded in growing sugarcane more cheaply than the Pathans, who have followed their simple method for many years.

Irrigation. The total average annual rainfall of the Peshawar District is only 13 inches, but a very large part of the valley's cane is grown on the banks of the Kabul river where the cultivators generally can have as much water as they desire from the canals which are maintained by themselves. The method of applying the water is rather wasteful but it is simple and efficient. The sugarcane-growers realize that the cane is built up by almost unlimited supplies of water in late September and October, provided this is associated with efficient drainage. They also know that no water should be supplied within 14 days of the date when the crushing of the cane begins. The irrigation of cane is quite well understood by the Peshawar cultivators.

Rotations. Clover, sugarcane, maize, wheat, clover, and so on is the most favoured rotation on the banks of the Kabul river, and no more suitable or profitable rotation has been found at the Peshawar Agricultural Station.

Implements employed in the cultivation of sugarcane. The steel inversion plough is successfully employed at the Peshawar Agricultural Station in uprooting sugarcane stumps, and to ensure deep tillage, but the cane-growers have not shown any inclination to take up the plough. They very reasonably point out that an inversion plough upsets the levels of their fields and is liable to entail more work and expense in re-adjusting the levels than is warranted by the increased yield of cane. There is no call for improved implements in the cultivation of sugarcane at Peshawar at present.

Harvesting sugarcane. Trans-border men and women cut the Peshawar cane for the cultivators, and in payment of their labour receive the cane tops that would otherwise rot on the land. An agricultural station need not seek a cheaper method of harvesting sugarcane than this.

Insects and diseases. Sugarcane-borers spoil a considerable part of the Peshawar cane crop, but the pests are perhaps not more troublesome in the North-West Frontier Province than in any country where cane is grown. The Pathans contend that cane which is planted in *shaftal* for a time entirely escapes the attacks of the cane-borers, and this belief has been very well confirmed at the Peshawar Agricultural Station. After a fallow, on the other hand, the young cane plants frequently suffer severely from borers, and it has been demonstrated at Tarnab that it is then profitable to collect the egg-clusters of the pests from the young canes.

Red-rot is present wherever cane is grown in the North-West Frontier Province, but the disease is not a seriously destructive one at the present time on the banks of the Kabul river. The cultivators know well that they can check the spread of the disease by discarding disease-affected cane sets when they plant their fields in March. The diseased cane is discarded very unwillingly, however, for cane seed costs from 6 to 12 annas per maund in March, after it has been preserved in clamps for two or three months. It is a remarkable fact that the thick cane that is now grown at Peshawar has been cultivated there to the entire exclusion of any other variety for over half a century.

Tests of varieties. After testing numerous varieties at Tarnab, the variety named D. 74, which is so extensively grown and so highly valued by the cane planters of Louisiana, is the only one that has rivalled the Peshawar cane in all-round merit. This Demerara seedling ripens earlier than the Peshawar variety, which it otherwise closely resembles. In a series of analyses that were carried out at Peshawar over a period of four years by Dr. Leather, it was determined that the Peshawar cane contains a high proportion of juice, with from 12 to 14 per cent. sucrose,

and that the cane is at its best in January. Treated in a bullock power Nahan mill in this month, the cane yields about 75 per cent. juice, and this contains about 13 per cent. sucrose, 1·5 per cent. glucose, and has a purity co-efficient of about 80.

Gur. The Poona method of making *gur*, that is frequently recommended and very well spoken of in South India, was tried at Peshawar in 1912, and found no more efficient and far more troublesome and cumbrous, and certainly more expensive, than the more adaptable Peshawar method. As the best Peshawar *gur* realizes a price second to none in India, the Pathan's method of *gur*-boiling appears to be satisfactory.

Cost of gur-boiling. The cost of making *gur* and placing it on the market is fully 60 per cent. of the cost of producing the cane. *Gur*, it has been found at the Peshawar Agricultural Station, can be made at a profit only where the young members of a family, the boys and girls, and women assist in making the sugar. *Gur*-boiling is not very profitable when stalwart men are hired to drive the bullocks, to feed the mill, to carry the juice, to make the *gur* balls, etc. The growers of large areas of cane, indeed say they would rather sell their cane than convert it into *gur*, if they could get a fair price for the crop.

Co-operative gur-boiling. In those North-West Frontier villages where sugarcane is an important crop, small groups or families of growers invariably co-operate in making *gur*, and this arrangement is satisfactory. In experiments that have been carried out elsewhere in India, it does not appear that *gur* can be satisfactorily and profitably made in a large factory, so there is no call at present to attempt to alter the Pathans' method of producing *gur*. At Peshawar, as elsewhere, *gur* will probably always be produced chiefly by the growers of small, isolated areas of cane. Where large blocks of cane can be grown in the North-West Frontier Province the growers state that they would prefer to sell their cane to a factory rather than convert it into *gur*, but some few cultivators, it has been observed, would like as much for their cane as they realize for this when it is converted into *gur*.

Length of the sugarcane-crushing season. On the banks of the Kabul river, where the sugarcane of Peshawar grows best and ripens earliest, *gur*-boiling begins on the 20th November or even earlier than this and proceeds busily till the middle of February. The average length of the *gur*-boiling season is 100 days. But experiments at the Agricultural Station have clearly shown that the cane-crushing season may be extended to 130 days without any loss of sugar if the crop is windrowed after rain falls in March. It also appears from the experiments that cane icontnues to ripen satisfactorily after the buds of the cane are killed

by frost in December, and that the cane in this state remains sound for two or even three months at Peshawar.

Potentialities in the production of refined sugar from cane at Peshawar. About 2,500 tons of refined sugar are annually imported to Peshawar by rail, and a large part of this is again exported, chiefly by way of the frontier passes from Peshawar. Most of the refined sugar comes to India from across the seas. By reason of its position, more than 1,000 miles from a seaport, Peshawar may always enjoy a considerable measure of protection for any refined sugar it produces. On the other hand, the price of coal and other imported commodities must always be greater at Peshawar than elsewhere in India where sugar is now produced.

It has been determined that the Peshawar cane is of good manufacturing quality ; that the cane is cheap ; that it is produced on compact areas ; that the facilities for transport, especially by water, are most exceptionally favourable at Peshawar; that the landholders desire to grow cane more extensively than they do at present, and they wish to sell the cane rather than to convert it into *gur*. A demand exists in the numerous cantonments of the frontier for a large quantity of rum which is now imported, and it would even be possible to use molasses in the preparation of service rations for artillery and cavalry animals, and for the animals of the Supply and Transport units. All these questions are being investigated, with the help of the expert officers of the Agricultural Research Institute at Pusa, by the Department of Agriculture in the North-West Frontier Province, and there is reason to hope that a sugar factory will be established on the Kabul river before very long.

II. Sugar-beet.

When experiments began at Tarnab in 1911, to find if refined sugar could be produced in the North-West Frontier Province, it was realized that even if the sugarcane proved to be of good manufacturing quality and other factors were favourable, a crushing season of 100 days only was hardly sufficient to permit a factory to work at a profit. At the same time it was known that many factories in the sugarcane world have a campaign of not more than 100 days. After some preliminary investigation, it was decided to carry out a series of experiments to find if sugar-beets could be successfully grown in the Peshawar valley, for it was realized that if beets could be supplied from the beginning of April till the end of June, the roots and sugarcane together would enable a factory in the North-West Frontier Province to work for 190 to 200 days, a length of campaign which few sugar factories in the world now enjoy.

The tests have confirmed very well the hope that beets of good manufacturing quality can be produced in Peshawar valley from early April until the end of June. No beets have yet been grown by the cultivators, but the trials that have been carried out at Tarnab on areas which have never been less than one acre have demonstrated—

(1) that it costs Rs. 60 to Rs. 70 to produce about 16 tons of roots per acre ; this price includes rent and all other charges ;

(2) that beets mature within a period of six to seven months, and contain from 15 to 16 per cent. sucrose when they are ripe ;

(3) that roots may be supplied to a factory from the 1st April until the end of June ;

(4) that sugar-beets may be advantageously included in the rotation of crops on the irrigated parts of the Peshawar valley;

(5) that the Peshawar cultivators who now grow chillies and sugarcane extensively would have no difficulty in growing beets ;

(6) that under irrigation the beet crop is a safe one, and it should be very profitable ;

(7) that the deep red alluvium, almost free of stones, which forms the greater part of the Peshawar valley, is suitable for the production of roots.

It may be added that the by-products in the manufacture of sugar from beets could probably be economically disposed of in the North-West Frontier Province.

III. General Summary.

(1) Sugarcane of good manufacturing quality can be produced in the Peshawar valley at Rs. 4 to Rs. 5 per long ton.

(2) Land and water are available on the banks of the Kabul river for the extension of sugarcane cultivation.

(3) The Peshawar cultivators are well skilled in the cultivation of cane.

(4) The landholders on the banks of the Kabul river desire to grow cane for a sugar factory.

(5) The manufacture of sugar would not affect the out-turn or the price of *gur* in the Peshawar valley.

(6) Circumstances are generally favourable to the manufacture of refined sugar at Peshawar.

(7) Sugar-beets with an average of 15 per cent. sucrose can be grown for Rs. 4 to Rs. 5 per ton in the Peshawar valley.

(8) Sugarcane and sugar-beets can be treated for the production of refined sugar in one factory.

(9) Sugarcane and sugar-beets would give a factory at Peshawar a working season of no less than 180 to 200 days.

31st May, 1918.

(11)

ASSAM.

(*a*)

(A. A. Meggitt, B.Sc., *Agricultural Chemist and Offg. Deputy Director of Agriculture, Assam Valley.*)

I. Mechanical Aspect.

In the matter of cane-crushing and *gur*-making, our efforts have been confined to the sale of a small 3-roller iron crushing mill capable of doing 2 maunds per hour and costing Rs. 65 in peace times. It is very efficient, giving an expression of 70 per cent. with medium thick canes. Some 54 of the mills have been sold during the last three years in the Assam valley.

The use of shallow evaporating pans in place of deeper vessels is also being pushed.

A factory for the manufacture of white sugar direct from the cane is being erected on the Kamrup farm, *vide* paragraph " Extension Areas " below.

II. Agricultural Aspect.

(*a*) *Survey and testing of local varieties under chemical control.* Several varieties, purporting to be local varieties, have been tested and many rejected at Jorhat in the past, and some are continuously grown against imported varieties for comparison. A good many of these so-called local canes are obviously importations from other parts of India. No complete survey of the canes of the province has been possible up to date. With the expansion of the Department this work will be taken up at Jorhat in the near future with a view to isolate pure types. A sport of one variety, Magh, has been obtained ; in field tests it is proving itself superior to its parent, making at least an equal plant crop, and a very much better ratoon.

(*b*) *Testing such imported varieties as appear prima facie suitable.* This work has been continued actively. The varieties under test include

Striped Mauritius, B. 376, B. 147, B. 208, Barbados A and B (numbers uncertain), B. 6450, B. 3412, B. 1529, Red sport of Striped Mauritius (2), Java (Hebbal), Java 247, Java 33A, Ashy Mauritius, and six other new varieties supplied by Mr. W. Maxwell to the Kamrup farm, whose names and origin were not communicated. Striped Mauritius, B. 376 and B. 147 continued to do well. These varieties were carried on to a factory scale on the Kamrup farm and gave a very good account of themselves, *vide* Kamrup Farm Report for the year ending June 30, 1917. Of the newer varieties, Barbados A, B. 6450, B. 3412 and J. 33A are most promising ; Barbados A gave over 39 tons stripped cane per acre from a tenth acre plot last year. J. 33A promises to be a very good cultivator's cane, germinating freely and cropping and tillering well. Many of these varieties have been given field plots this year for the first time. This work is proceeding both in Kamrup and at Jorhat.

(*c*) *The distribution of the best varieties so determined.* The demand throughout Assam for proved varieties increased enormously, and now far exceeds the supply. In 1916 about 1 lakh of cuttings of Striped Mauritius, B. 376 and B. 147 were distributed ; this year over $3\frac{1}{4}$ lakhs were disposed of and this did not meet the demand which is almost entirely the result of actual field demonstration of the superior merits of these canes over local varieties.

(*d*) *The demonstration of improved mechanical methods.* Demonstrations in the districts of the small three-roller iron bullock mill referred to above and of the use of the shallow evaporating pan have been continued with success. The demand for these mills is in consequence a constantly increasing one, and in this connection there would appear to be a good field for co-operative societies.

Mills and pans are also hired out at a nominal rate.

(*e*) *The study of questions of tillage, watering, manuring, and drainage, in the light of local conditions, so as to increase the average out-turn per acre.* As regards tillage, experiments have continued in planting methods, using the ridge and furrow system, and varying the spacing of the sets in trenches 3,′ 4′ and 5′ apart, respectively. In the result about 8,000 sets per acre planted approximately 2′ apart centre to centre in rows 3′ apart has given the biggest out-turn.

Experiments in 1916 indicated that not only the number of sets per acre, but also their disposition in the row, may exert considerable influence on the crop. This is being further examined in wide *versus* narrow trenches on the Java model.

Demonstrations in the districts have proved that planting in rows 3 feet apart gives bigger crops than the usual local method of planting in rows so close as to make intercultivation difficult.

Rotation experiments at Jorhat have proved the value to the succeeding cane crop of the following procedure in the year preceding cane —a green crop in the rains, succeeded by a catch crop of rape (*Brassica campestris*) sown early October and ploughed in mid-November, followed by a deep fallow till planting time in February or March.

As to manuring, experiments have continued on :—

(1) Cake *versus* cowdung ;

(2) Cake and cowdung *versus* cowdung alone ;

(3) Raw mineral phosphate in the rotation.

Results will be found in the Jorhat Farm Report for 1916 and 1917.

Respecting drainage, no actual experiments have been made. In view of an outbreak of a *sereh*-like disease some years ago, the drainage of all the cane areas has been yearly improved with an almost complete disappearance of the disease.

III. Extension Areas.

Since the Kamrup farm experiment was last brought before the Board, very great progress has been made, and an extension of operations sanctioned up to March 1919. The disposal of the crop up to that time has been provided for in a contract made by the Local Administration with Mr. W. Maxwell, the cane being sold to him on a sliding scale based upon its sucrose content.

The drainage difficulties which beset us two years ago have been surmounted. With the help of Mr. Milligan (then Imperial Agriculturist) a drainage scheme was worked out, and put into operation early in 1916. This is described in paragraph 11 of the Kamrup Farm Report for 1916. It is sufficient to say here that it has worked admirably ; the heaviest falls of rain are quickly removed and the water table has been considerably lowered. During 1916 some 270 acres were under cane—Striped Mauritius, B. 376 and B. 147—and though thin in places, it made a very good average crop. On my computation the crop averaged about 20 tons per acre all over ; it was much higher than this on certain areas which had been reclaimed and opened out 12 months previous to planting, and lower in certain other more recently reclaimed and lower lying parts. Owing largely to delay in the completion of the contract with Mr. Maxwell, a large part of this crop had perforce to be thrown away, rather less than 800 tons being converted into *gur* ; in addition some $2\frac{1}{4}$ lakhs cane sets were distributed from the farm.

The cane was very healthy and ripened off its juice perfectly ; by January 1917 the ratoons contained upwards of 14 per cent. sucrose on cane, while by the end of February the plant cane averaged about

15 per cent. sucrose on cane. For further details see report for 1917.

At present the temporary *gur* factory is being converted into one capable of making white sugar direct from the cane, and it is hoped to convert the crop now on the ground into white sugar during the coming cold weather.

Out of some 600 acres now in cultivation about 500 acres are under cane, plant and ratoon equally. The ratoons came away well, but the cane planted in February and March 1917 suffered somewhat from the drought which followed in March and April this year. The rainfall was also much shorter than usual in May. For these reasons the crop is thin in parts and will probably not come up to last year's general level. From our experience already there is every reason to believe that, given a suitable rotation, the cane crops in the next rotation will be a considerable improvement upon those of the past two years. What we are aiming at is 1,000 acres under cultivation, half in any one year to be under cane and half under green crops recuperating. If the experiment terminates in 1919 or the farm is disposed of then, we shall not have had time even to complete a single course of the rotation, nor to determine whether such a 1,000-acre scheme is beyond the limits of our set of cultivating tackle, nor yet to explore the capacity of the soil for continued production.

4th September, 1917.

(*b*)

(J. McSwiney, I.C.S., *Director of Land Records and Agriculture.*)

I have nothing to add to the above note except that financial considerations have been the deciding factor in the intention to dispose of the sugarcane farm in February 1919. We shall have spent over 3 lakhs on the experiment by the end of March 1918 and not improbably 4 lakhs by February 1919 : this is a large sum for a small province and I am doubtful whether, if the present financial stringency continues, we could be expected, without assistance, to continue the farm, especially as the original proposal was to limit the expenditure to 2 lakhs and to complete the experiment in three years.

8th September, 1917.

(12)

BURMA.

(T. COUPER, I.C.S., *Director of Agriculture.*)

Economic conditions have become more favourable to the development of the indigenous sugar industry : imports of foreign sugar were, in 1916-17, 260,000 cwt. as against 430,000 cwt.* in 1914-15 and the customs tariff has been doubled. In the two years the area under cane in Burma has risen from 15,362 acres to 18,136 acres.

On the mechanical side nothing has been done by the Department to introduce improved crushing or boiling plant. But a factory to turn out four tons of white sugar and two tons of *jaggery* daily is being erected by private enterprise in the Toungoo District.

The indigenous canes have been collected and are being studied at the Hmawbi farm in Lower Burma. The collection was examined by Dr. Barber at the beginning of this year. He found all Burmese canes to fall under five types, only one of which is a true tropical cane. He was of opinion that better varieties could be substituted for the local canes, and exotics sent by him from Coimbatore are now under trial both in Upper and Lower Burma. No experiments have been made in the production of white sugar, nor have the chemical and agricultural aspects of the palm sugar industry been investigated.

On several of the seed farms and experimental stations cane is being grown, in part as a demonstration. One farm distributed 48,000 sets through the District Agriculturist. In another district a Co-operative Societies Union has been induced to place 30 acres under cane. At the Hopin farm in the north of Upper Burma the out-turn was at the rate of 29 tons an acre ; cattle manure at the rate of 9 tons an acre was used. The Local Government is contemplating the opening of a colony for ticket-of-leave prisoners in this neighbourhood where cane cultivation will be one of the main occupations. The capitalist who is erecting the factory mentioned above has been given much assistance by Mr. McKerral, and Dr. Barber also helped him in determining where the factory could best be located. In order to ensure at the beginning an adequate supply of cane to the factory the Local Government has granted revenue concessions.

17th September, 1917.

* The imports of sugar include molasses, confectionery and saccharin which totalled 19,000 cwt. and 51,000 cwt. in 1916-17 and 1914-15 respectively.

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INTRODUCTION

THE question of the best means of rapidly increasing the outturns of food crops by methods within the power of the Agricultural Department was discussed at the meeting of the Board of Agriculture held at Poona in December 1917. No resolutions on the subject were passed, but the discussion was interesting and the papers submitted by the various provinces contain many suggestions of permanent value. They are now published in this volume in the hope that they may prove suggestive to agricultural workers. They give an indication of what has already been done in the different provinces and throw out suggestions as to measures which could rapidly be adopted with a view to insure a quick increase in foodstuffs. In times of national emergency, such as the present, it is necessary that our Agricultural Departments should be able to meet a sudden demand, and a perusal of this volume will indicate the various methods which can be adopted.

The methods by which the produce of a country can be increased fall into two classes :—

In the first place, the food supply of a country may be increased by substituting food crops for fibre or other non-food crops or by the breaking up of new lands formerly not under cultivation. These, however, are rather administrative questions dependent either upon the arbitrary order of Government that cropping should follow a certain scheme or on the availability of waste lands formerly uncultivated.

The second group of methods which more properly come within the scope of the Agricultural Department are :—

(1) introduction of improved varieties,

(2) manures, and

(3) better cultivation,

and in the papers which appear in this Bulletin the efforts of the various Agricultural Departments along these lines are recorded. It must be remembered that there are considerable

limitations to the use of manures. There are also limitations to intensive cultivation on account of the shortage of cattle, while it is probably dangerous to suggest revolutionary changes in well-established schemes of rotation. Advance along these lines must be gradual and the most hopeful prospect of a rapid development depends on the evolution of improved high yielding varieties of crops such as the Pusa, Punjab and Central Provinces wheats and Bengal, Madras, Central Provinces and Burma paddies, combined with an effective organization for the rapid dissemination and distribution of these improved varieties.

J. MACKENNA,

Agricultural Adviser to the Government of India.

SIMLA :

September 10, 1918.

The best means of rapidly increasing the outturns of food crops by methods within the power of the Agricultural Department.

CHAPTER I.

BENGAL.

(S. Milligan, M.A., B.Sc., *Director of Agriculture.*)

The following are the normal areas under the principal food crops in the province as given in the Season and Crop Reports :—

	Acres.
Winter rice	16,622,500
Aus rice	5,031,500
Boro rice	370,000
Gram	240,000
Wheat	205,000
Barley	140,000
Other food grains	1,730,000

It will be noticed that what is termed the winter rice crop is by far and away the most important. Under this heading are included two different crops :—

(1) the transplanted "aman";
(2) the long-stemmed deep water paddy.

Unfortunately both are returned together, and no separate figures can be given for each variety. A very rough estimate of the ratio between the two may be taken at 5: 3, given 6 million acres under deep water and 10 million acres under transplanted "aman."

The summer or "aus" crop is the next in importance, and then the "boro" or early summer crop which occupies the place of least importance amongst the rices.

The principal *rabi* (winter) crops are wheat, barley and gram.

The *rabi* crop, however, does not approach the *kharif* (monsoon crop) in importance in Bengal, owing to the fact that the great bulk of the land is low-lying and suited for rice only.

The Agricultural Department has confined its investigations mainly to the examination of the varieties of transplanted rice. Owing to the redistribution of the provinces, the Agricultural Station at Dacca now serves Eastern and Western Bengal in place of Eastern Bengal and Assam. This has led to a much greater development of the work as applied to Eastern Bengal. While, therefore, a very thorough examination of the Eastern Bengal rices has been made, it has not been possible to take up similar work in Western Bengal. A very marked success with great economic possibilities has, however, attended the work on transplanted rice of the Botanical Section at Dacca. Examination of the different Eastern Bengal varieties (over 2,000 have been dealt with) has revealed striking differences in yield, and several high yielding strains with other desirable characters have been isolated and multiplied. The pure line *Indrasail* has been finally selected as being the best all round and suited to the largest area. This variety yields a medium quality rice similar to what is commonly consumed by the ryots, and, in addition to being a very high yielder of paddy, yields a high percentage of husked rice. In the opinion of the Economic Botanist, as a result of careful computation, the average yield of *Indrasail* over the varieties commonly grown in the districts of Eastern Bengal is about six maunds per acre. From further tests at the agricultural stations and in the districts a safe estimate of the probable increase due to the substitution of this variety for those of approximately equal quality would be $4\frac{1}{2}$ maunds of paddy or 3 maunds of husked rice per acre. A rough computation of the acreage to which these figures apply in Eastern and Northern Bengal alone is from 4,000,000 to 5,000,000 acres, say, 4,500,000. Thus, if our calculations hold good over this area, an increase of 500,000 tons would follow from the substitution of the *Indrasail* for local varieties.

The work on *aus paddy* has not reached a stage at which definite conclusions as to yield, etc., of the different pure line varieties are possible.

No other crops have been examined as to yield.

The possibilities of increasing the outturn of food crops in the near future through improved varieties is therefore limited to the increased use of high-yielding varieties of *transplanted rice*. The apparent limits

to this are indicated by the figures of 4 to 5 million acres in area under the crop and half a million tons of cleaned rice in outturn. These figures may, however, have to be raised as the variety in question has been tried this year for the first time in Western Bengal and may yet prove a success in that part of the province.

Little can be said of the *present rate of increase* in the area under the new variety. The first outside distribution of seed was made in 1916 at various places along the Dacca-Mymensingh Railway line. The crop proved a success and the variety was at once recognized as being a superior yielder. As a result, seed was in request in the immediate vicinity of the centres of distribution. The apparent conclusion is that, if seed of this variety can be distributed from a sufficiently large number of centres, a very large area may be expected to be under the crop in the succeeding year. Progress, in fact, will bear a close relationship to the number of centres of distribution.

The propagation ratio of transplanted paddy being about 70 : 1, and one maund of paddy seed being sufficient for three acres of land, it follows that the produce from 20,000 maunds of paddy would be sufficient to seed 4,200,000 acres in the succeeding year. The effective distribution of 20,000 maunds of *Indrasail* paddy would thus result in the production of enough seed of the improved variety for almost the total area to which it applies. It remains to find an efficient organization to distribute the seed so as to prevent " overlapping " and to promote the expansion of the area inside definite limits. The present policy of the Department is to make as much use of the village panchayets as possible for this purpose. This agency has this obvious advantage that it covers the district completely and uniformly. We may be therefore sure that a seed distribution through the panchayets will be exhaustive. It will be also possible for the panchayets to distribute the seed uniformly throughout their jurisdiction and to make it clear to growers that this seed is being distributed for the sake of further propagation. The variety, once introduced into the village as a unit, must be left to make its own way by virtue of its qualities. The first object is, therefore, the introduction, into every village where transplanted paddy is grown, of a small quantity of the seed of the improved variety.

Two thousand maunds of the *Indrasail* paddy have been distributed according to the above scheme this year (1917). It is proposed to distribute the remaining 18,000 maunds in the next two seasons as follows :—

6,000 maunds in 1918.
12,000 „ „ 1919.

It is thus hoped that in 1919 the distribution scheme will be completed, and that in the harvest of that year there will be sufficient seed for all requirements methodically distributed throughout Eastern and Northern Bengal. If the variety proves suitable for Western Bengal further provision of pure seed will be necessary.

Financial provision.

The present budget provision covers the scheme up till 1918. By utilizing our existing agencies for seed-growing and distribution to the fullest extent, we will be able to complete the distribution of 8,000 maunds of seed in small quantities in the summer of 1918. The distribution of an additional 12,000 maunds will, however, mean going further afield into new districts and the cost of raising additional seed.

A scheme to enable the Department to complete its first distribution in 1919 has been approved by the Bengal Government. This includes the appointment of new District Agricultural Officers, the establishment of three small farms to act as nuclei of seed areas, provision for the purchase of bags, for packing, railway freight, etc. The estimated total cost of the scheme amounts to Rs. 1½ lakhs, but this includes a sum of Rs. 26,000 for jute seed which it is proposed to distribute through the same agency as the paddy seed. The proposal has been approved by the Bengal Government. It is not certain, however, that funds will be available in 1918. The production of pure seed for distribution will be partly effected through existing farms by using all available areas for the purpose, and partly by arrangement with outside growers under the control of the Department.

From the foregoing it appears possible to increase vastly the outturn from the transplanted rice area in Eastern and Northern Bengal by the introduction of the new *Indrasail* variety, the full effects of which would, however, not be felt before the harvest of 1920. If the scheme approved by the Bengal Government is given effect to through financial provision being made in this year's Budget, the maximum possible rate of expansion will have been attained, so long as no new localities are found suitable to the *Indrasail* variety. Extensions to new localities as, for example, the Western Bengal districts, will require funds in proportion to the areas involved.

Increase of production per acre through the extended use of manures.

An extended use of manures such as castor-cake and bonemeal is to be looked for, but such will necessarily be very gradual for years to

come, and no rapid expansion is possible except by free distributions on a wholesale scale, involving an enormous supervising staff and great waste.

Similarly no rapid developments in the adoption of cultural methods leading to increased crop outturns can be expected without a large increase in the district staff. We have practically only one recommendation in this direction, *viz.*, the use of *dhaincha* (*Sesbania aculeata*) as a green manure for transplanted paddy. This is being demonstrated in Western Bengal. Progress however has been slow and will necessarily continue so owing to lack of staff, but any attempt to inflate unduly the numbers of the demonstrating staff without previous preparation is not likely to lead to successful results.

New crops.

Some success has been met with in the introduction of groundnuts on culturable waste lands in the districts of Birbhum and Bankura, but here again rapid expansion cannot be looked for owing to labour difficulties. After several years' work the area under this crop amounts to some hundreds of acres only. No other new food crops have been introduced, nor have we any to recommend.

Suggestions for the increase of areas under food crops at the expense of areas under other crops are all open to serious economic objections. There exists, for example, in Eastern and Northern Bengal a fluctuating area which alternates between jute and rice cultivation, the crop being determined largely by the relative values of rice and jute. The balance between the two crops is rapidly adjusted to meet changing conditions, a decrease in the jute area and a corresponding increase in that under rice following low prices for jute fibre, and *vice versâ*. The controlling factor is therefore relative values and nothing short of measures to adjust the balance in favour of rice would have the slightest effect.

Summary.

The only practical method at hand of rapidly and materially increasing the food products in Bengal appears to be in the increase of the area under the higher-yielding varieties of transplanted paddy, and this can be most readily effected by the distribution on a wide scale of the new Dacca *Indrasail* variety in Eastern and Northern Bengal and in other districts where it may be found superior to existing varieties.

Normal area under crops in Bengal.

Food-grains—	
1. Rice—	
(*i*) Bhadoi or aus—harvested from mid June to mid November	5,031,500
(*ii*) Aman or winter—harvested from mid November to end of February	16,622,500
(*iii*) Boro or summer—harvested from 1st March to mid June	370,600
Total	22,024,600
2. Wheat	205,400
3. Barley	140,700
4. Jowar (*A. Sarghum*)	2,400
5. Bajra (*Pennisetum typhoideum*)	6,900
6. Maize	100,200
7. Gram	275,000
8. Other food-grains (including pulses and *marua*) (*Eleusine coracana*)	1,730,100
Total	24,485,300
Oil-seeds—	
9. Linseed	226,600
10. Til (*Sesamum indicum*)	325,700
11. Rape and mustard	1,352,400
12. Others	65,900
Total	1,970,600
13. Condiments and spices	205,500
Crops grown for sugar—	
14. Sugarcane	256,100
15. Others	129,700
Total	385,800
Fibres—	
16. Cotton	44,600
17. Jute	2,643,800
18. Others	44,500
Total	2,732,900
19. Mulberry	29,700
Drugs and narcotics—	
20. Tea	143,500
21. Tobacco	408,800
22. Cinchona	2,500
23. Indian hemp	1,100
24. Others	900
Total	556,800
25. Fodder crops	140,900
26. Fruits and vegetables (including root crops)	715,200
27. } Miscellaneous crops { Food	482,200
28. } { Non-food	340,600
Total cropped area during the year	32,045,500

CHAPTER II.

UNITED PROVINCES.

(The Hon'ble Mr. H. R. C. Hailey, C.I.E., I.C.S., *Director of Land Records and Agriculture.*)

It is understood that the scope of this enquiry is limited to such methods as the Department may of itself adopt, and wider measures that might be taken by Government acting through other Departments such as the Irrigation Department are not included. The possible means which suggest themselves for the increase of food production are—

(1) increase of the area under cultivation;

(2) substitution of food for commercial crops;

(3) increase in productivity of the soil.

As regards (1) it may be briefly dismissed as a matter in which for the immediate future the Agricultural Department could play little part. The cultivated area in the United Provinces, while it fluctuates with the season, over a series of years shows little change. In the closely populated districts little land of value, outside the village grazing lands, remains uncultivated; where there are still tracts lying waste problems of unhealthiness of climate and scarcity of cultivators arise. The figures of the past few years, *viz.*, 35,646,036 acres in 1910-11 as compared with 35,633,086 acres in 1915-16, do not point to any progressive increase in cultivation, and expansion will only take place slowly as land is cleared and improved in various ways. Without going further into detail it may be said that old fallow, which *primâ facie* seems to offer possibilities of expansion, is considerable in extent only in the sparsely populated parts of Bundelkhand and Mirzapur. The only suggestion which can be made in this connection is that by the use of tractor ploughs land suitable for wheat growing which is now overrun with *kans* (*Saccharum spontaneum*) could be brought under cultivation. The clearing of this land is generally beyond the power of bullock-driven ploughs.

(2) The proportion of non-food to food crops in these provinces is not high. The largest of the former, *viz.*, cotton, covers 1 to $1\frac{1}{2}$ million acres out of the net cropped area quoted above. The principal non-food crops are cotton, opium and hemp. Opium competes with wheat to a limited extent, but the total area is relatively small and produce is now being used for medicinal purposes. Cotton is a rotation crop with wheat, and after it is taken off the ground in canal districts is usually followed by a catch crop of peas or mixed peas and barley. Hemp is almost invariably followed by a *rabi* food crop. There is nothing therefore to be gained by any attempted substitution of food crops for either.

(3) There remains therefore the question of increasing the output by such measures as are directly within the power of the Agricultural Department.

Undoubtedly the most efficacious would be the provision of water in dry and precarious tracts at present under poor and irregular cultivation, or where the existing class of wells yield so little water that intensive cultivation is impracticable. This has been part of the regular work of the Department since its initiation, and has received considerable impetus by the appointment of an Agricultural Engineer and the introduction of tube wells. Though over a series of years it is possible to point to definite improvement, operations necessarily proceed slowly.

Other measures include the distribution of heavier yielding varieties, improvement of methods of cultivation, introduction of rotation systems which will permit of a larger area of food crops being grown.

Taking first the *kharif* crops, among these rice occupies the principal place. Not a great deal of work has been done on this crop ; but certain types have been selected which, if kept pure, promise the best yield for particular varieties. The main obstacle, however, to effecting any improvement in the methods of cultivation is the precariousness of the crop, which, except in case of the early varieties, is dependent on late rains. For the five years prior to 1915 the early withdrawal of the rains from Upper India had been a common feature of the monsoon, and the security of the crop really depends on a fuller utilization of the natural supplies of water within the rice-growing tracts. Until such security is to a greater measure ensured, rice-growing will continue to be regarded much in the nature of a gamble, and the cultivators will be reluctant to make any efforts to improve their method of cultivation. The extreme dependence on seasonal conditions is common to all crops sown on the rains and the most feasible lines of development appear to lie in the encouragement of early sown crops on irrigation and improvement of *do-fasli* (double-cropping) cultivation, particularly in the growing of wheat after maize and *jowar* for fodder. In the last

direction a good deal of work has been done by Mr. Burt and it has been demonstrated that with adequate cultivation and manuring of the *kharif* crop wheat crops of good quality can be produced after *jowar* grown for fodder and maize. Wheat following maize is a common enough rotation, but the poverty of the second crop has passed into a proverb, though it has been clearly shown that a marked improvement could be effected. A more intensive cultivation, however involves use of better implements and more manures and, as in case of other improvements of methods of cultivation, turns largely on economic factors. The provision of cheap cake to supplement the inadequate supply of manure such as *mohwa* (*Bassia latifolia*) cake for maize would be a step of great importance.

As regards the *rabi* crop, the introduction of heavier-yielding varieties offers best promise of an immediate increase in yield of food crops. In Pusa 12 the Department have undoubtedly a heavier yielder than *deshi*, and it is being put out on as large a scale as possible. Pusa 4 is also of considerable value in more limited areas, and in Cawnpore No. 13 we have a third wheat of considerable promise for certain conditions. About 100,000 acres were under these crops last season (1916-17) and the area will be increased during the coming *rabi*. A fair estimate of the minimum increase would be about two maunds per acre, and this represents some, if not a great, increase to the provincial yield. The increase in years when rain in heavy wind occurs in late February or March is greater. Some of the selected barleys for the eastern districts have proved good yielders and are being put out so far as seed supply available permits. Considering the length of time required for raising the general low standard of yield and the obstacles to be overcome in the way of poverty of the agriculturists, uneconomic holdings, etc., the above, *viz.*, the distribution of heavier-yielding varieties, seems the most important line of advance which can be suggested for an increase in production in the immediate future. This involves a somewhat elaborate organization for the distribution of reliable seed which in itself is a material aid in the same direction. Hand in hand with the organization of seed distribution, a great deal of demonstration work in the direction of general improvement of cultivation is being carried on, including correct and adequate tillage, better methods of irrigation, and, in suitable localities, green-manuring.

The question of compact and properly aligned holdings forms a separate subject for discussion by the Board. It is unnecessary to refer to it here as the limitations which the present small and scattered holdings impose on crop yields are generally recognized.

CHAPTER III.

PUNJAB.

(The Hon'ble Mr. C. A. H. Townsend, B.A., I.C.S., *Director of Agriculture and Industries.*)

In this province by far the most important of the food crops grown is wheat. The latest Season and Crop Report of the province gives the following areas under the different food grains in the year 1916-17 :—

	Acres.
Rice	1,063,598
Jowar	1,493,714
Bajra	3,033,211
Maize	1,270,420
Wheat	9,467,240
Barley	1,153,061
Gram	5,115,944
Sugarcane	414,110

Rightly, therefore, the Agricultural Department has as yet devoted most of its time and attention to wheat among the food grains. The methods adopted for improving the crop are two. The first is by encouraging the growth of varieties yielding more per acre than those they displace. The second is by the introduction of improved methods of cultivation.

As to the first method, two wheats have been found to give from half a maund to three maunds an acre more than local varieties in different tracts of the province. These are Punjab 11 wheat which has shown itself well suited to the great canal colonies, the principal wheat-growing tracts of the province, and Pusa 12 wheat which is becoming deservedly popular in the central submontane districts, such as Hoshiarpur, Jullundur and Gurdaspur. Under Punjab 11 the Agricultural Department had 97,000 acres last year (1916-17) : under Pusa 12,10,000 acres. Considerably larger areas are under these wheat this year. The Department will continue to encourage their growth and Government has been asked to sanction a grant of two lakhs of rupees in the coming financial year to enable it to buy large quantities

of pure seed of these varieties at harvest time to sell to cultivators at sowing time.

These wheats are certainly not the "last word" in wheats, even in the tracts in which they are grown, and the efforts at present being made by the botanical and agricultural staff of the province to discover wheats better than them will be continued.

For the south-east of the province the Hansi farm is trying to produce a suitable wheat. The farm has been established too recently to expect results yet: but the matter is receiving constant attention. And for the great wheat-growing tract in the north of the province, as Rawalpindi, Government has sanctioned an experimental farm, to be established at Hasan Abdal as soon as circumstances permit.

The second of the two methods of increasing the outturn, mentioned above, is the introduction of improved methods of cultivation. Briefly these methods are the introduction of furrow-turning ploughs: the use of harrows, particularly for young wheat, but also for breaking up the crust on fallows after any rain: interculturing implements: the use of reaping machines in the canal colonies in years when labour is scarce and dear: and the sowing of crops in lines, particularly maize, to facilitate interculture. Much of the wheat grown in the canal colonies is already sown in lines. All these measures tend to increase the outturn per acre, some more than others, and all receive constant attention. The rise in the price of implements imported from Europe and America on account of the war has however checked their sale: some indeed are unobtainable. And efforts are being made to evolve improved implements which can be made, at inconsiderable expense, by village carpenters and blacksmiths, to replace the expensive imported article.

Simple harrows and sowing drills have thus been made at Lyallpur and are becoming popular. The harrow costs about Rs. 12 to make: it is at present being sold at Rs. 8 to encourage its use and some hundreds have been sold in the short period of less than a year since they were introduced. Work on these lines will continue. Apart from wheat, the better cultivation of maize, as I have just said, receives attention: long-eared Australian *bajra* (spiked millet), which yields considerably more per acre than the ordinary millet, is attaining considerable popularity: groundnuts are being tried in light land and work is in progress on sugarcane and rice.

There remains but little more to say. The terms of the reference—the best means of rapidly increasing the outturn of food crops within the power of the Agricultural Department—to which this is a reply, are

not broad, and the words "rapidly" and "within the power of the Agricultural Department" are important. I will, therefore, only make mention of other proposals or methods which, though eventually undoubtedly increasing the food supply of the province, will either not do so rapidly, or depend, either entirely or to some extent, on agencies other than the Agricultural Department. In the former category falls the practice of green-manuring soils lacking in humus, which the Department advocates; the large schemes of reclamation of alkali and other barren soils, with which the name of the late Mr. Barnes will be ever connected; and proposals to increase well irrigation, whether by putting down pipes in existing wells, or entirely new tube well installations. In the latter fall those large irrigation projects of new canals in the province, particularly the great Sind Sagar project of irrigating the sandy Thal of Mianwali and Muzaffergarh from the Indus, at which the Irrigation Department is working, and minor changes in the practices of the Irrigation Department which the Agricultural Department advocates. These include the remission of the charge for a single watering taken during the summer months, when water is generally abundant, for ploughing purposes even though it be not followed by a crop. This is known as the "Vahn" rate. The more cultivation land gets the better, and the remission of this rate would certainly stimulate cultivation. Other such changes the Agricultural Department would like to see introduced are a charge for a single watering for gram, which would of course be less than the usual charge: this would probably stimulate the growth of gram in canal tracts, and the more this beneficial crop be grown the better: and the other is the gradual introduction of a system of charging for irrigation water by volume instead of, as at present, by crop. This change would certainly tend to economy in the use of water. Not only would the present canal crops be thereby benefited, but water would become available for land which at present produces little or nothing for need of it.

NORTH-WEST FRONTIER PROVINCE.

(W. Robertson Brown, *Agricultural Officer.*)

I fear I am unable to make any really new or useful suggestions on the best means of rapidly increasing the outturns of food crops in India. The area sown with cereals to a large extent depends on the rainfall, or perhaps more especially on the power of the cultivators to make prompt

use of this. It is rare indeed that sufficient rain to germinate wheat does not fall in September, October, or November, in the North-West Frontier Province or in the Punjab, but the cultivators are hardly ever able to sow more than a small part of the area on this rainfall. At present the large landholders do not farm their own land, and their tenants, unaided, are too poor or hold their land on too unfavourable terms to set machinery to work that would give them full advantage of the rainfall. In my opinion a very large part of India's unirrigated cereal crops will be produced by the aid of up-to-date implements and machinery when the landholders farm more of their own land or take active interest in its cultivation. Meantime it might be pointed out to the landholders that they are failing in their duty to their land at the present time, and that they could hardly subscribe to the Empire's weal in a more useful manner than by increasing the produce of their holdings.

The outturn of wheat often depends on the efficiency of the irrigation canals. For example, the yield of grain drops well over a maund per acre per week in each week that passes after the 5th November which is the optimum sowing date in the North-West Frontier Province. Every year the possible outturn of wheat on irrigated land is reduced by hundreds of thousands of maunds by the inability of the canals to give water just at the right time for sowing. It is of course not possible to give every one water at the most propitious moment, but the need for timely irrigation to ensure the best outturns in the autumn should be borne in mind by every canal officer.

Assuredly the new varieties of wheat, maize, etc., that are now being distributed in the provinces will in time increase the outturn of food crops, but rapid increase in India's production cannot be effected in this manner. I have no hesitation in stating that on most of the land I have seen these past twelve years, without new varieties, without more manure than is now used, and actually at a decreased cost of production, the landholders and cultivators could increase their outturn within twelve months' time by probably 10 per cent. if they would exert themselves ; if they would *really cultivate* their land. The apathy of the cultivators, I am afraid, is mostly due to the lack of incentive to do better work, for many of them are hopelessly in debt or hold their land on lease for periods which are so very short that they cannot afford to put work or money on their crops.

I am of opinion that the production of food crops in India can be quickly increased by rousing the interest of the landholders in the matter, and making it plain that this is their first duty to the Empire at present. In passing through the wheat-growing tracts of India, I have lately seen large quantities of agricultural produce lying exposed to the weather

on railway platforms and sidings. No doubt the accumulation of grain is somewhat larger than usual owing to unavoidable congestion of goods traffic, but I am afraid nevertheless that much available grain is annually lost by the lack of suitable storage at the railway stations.

Then I would suggest that an expert entomologist should settle down at Karachi until some method of reducing the awful destruction wrought by the grain pests there has been found and put in operation. In December last (1917) I saw vast numbers of wheat bags outwardly alive with grain pests at the Karachi railway siding.

CHAPTER IV.

CENTRAL PROVINCES.

(D. Clouston, M.A., B.Sc., *Officiating Director of Agriculture.*)

Three separate notes by Mr. R. G. Allan, M.A., Principal, Agricultural College, Nagpur, Mr. D. Clouston, M.A., B.Sc., Deputy Director of Agriculture, Southern and Western Circles, and Mr. G. Evans, M.A., Deputy Director of Agriculture, Northern Circle, Jubbulpore, are given below. The Northern Circle roughly represents the wheat tract of the provinces, the Southern Circle the rice tract, and the Western Circle the *jowar* and cotton tracts.

(*a*)

(R. G. Allan, M.A., *Principal, Agricultural College, Nagpur.*)

The only known methods of increasing the outturn of any crop per acre are tillage and drainage, manure and the introduction of more prolific varieties. The Department has been at work on all these for the last few years. Certain forms of tillage are better, certain manurial treatments have been proved and demonstrated, and better yielding types of paddy, wheat, *jowar* and gram are available and are being sown on a limited scale and pushed as far as the limited staff permits. I do not fancy these can be pressed much faster. The first is dependent on cheap iron and an alteration of land holdings to become widely used, the second is affected by the need for fuel and the limited capital at the cultivator's disposal, and the last is going forward as rapidly as is possible. I doubt if the rapid strides effected in a crop like cotton can be repeated in wheat and paddy, and any such development is linked with the growth of the co-operative spirit. Food crops in Berar again have to compete with a highly lucrative cotton equally wanted and only replaceable by grain in the event of heavy subsidies. Paddy can be increased in yield as has been shown at Labhandi by transplanting, manure and irrigation and selection; the increase of output is dependent on the extension of

irrigation. Wheat indeed represents the only dry crop of a food type of which the price is dependent on an external market demand. In every other case they are, I think, subsidiary to fibre or oil-seeds, for both of which the demand is steady and good. I do not look on the rapid increase of outturn of food crops (both per acre and for the country as a whole) as likely to be possible, though a gradual increase will undoubtedly in time be effected by the further expansion and development of the Agricultural Department.

(*b*)

(D. CLOUSTON, M.A., B.Sc., *Deputy Director of Agriculture, Southern and Western Circles.*)

The chief food crops of the Central Provinces are rice, wheat, *jowar*, pulses and sugarcane. The outturn of these could be increased very much by (1) better cultivation, (2) irrigation, (3) introducing more prolific varieties, (4) seed selection, (5) manuring, (6) double-cropping, (7) protecting crops which are damaged by wild animals, and (8) increasing the area under food crops.

(1) *Better cultivation.* Over the greater part of the Central Provinces rice is sown broadcast ; $3\frac{1}{4}$ million acres are cultivated in this way in Chhattisgarh alone. Transplantation with "single" seedlings increases the outturn by from 400 to 500 lb. of grain worth from Rs. 12 to Rs. 15 per acre approximately. If it were possible to get even 50 per cent. of the rice area of this division transplanted, the outturn would be increased by at least 300,000 tons of paddy worth approximately two crores of rupees per annum. After 10 years of hard work the Department of Agriculture has only been able to get 40,000 of the 3,250,000 acres transplanted in this division, and I do not anticipate that progress in this direction will be much accelerated in the near future. The better cultivation of the land with improved implements would undoubtedly lead to a big increase in the outturns of all the food crops grown, but with the limited means at their disposal the poorer cultivators who most require our assistance are not able to purchase such implements, unless they are financed by Government. Government might very well do more than it is doing at present in the way of granting *taccavi* to foster the introduction of improvements along these lines. If a substantial sum were placed at the disposal of the Department of Agriculture to be given out for agricultural improvements, much could be done in a comparatively few years in the way of introducing better implements, better seed and better methods of cultivation generally. Hundreds of thousands

of acres in the Central Provinces at present over-run with *kans* grass (*Saccharum spontaneum*) and other troublesome weeds, could be made to produce large outturns of food crops, if properly cultivated. Over a thousand iron ploughs have, within the last 10 years, been sold by the Department in the Western Circle where the cultivators are well-to-do and can afford to purchase such implements.

(2) *Irrigation.* Nearly all the food crops are benefited by irrigation. In the Central Provinces the area commanded by irrigation was till lately very small. It has been increased enormously within the last 12 years as a result of the numerous irrigation works constructed by Government, more especially in the Chhattisgarh and Nagpur Divisions, where there are three very large canal schemes now nearing completion. These three large schemes are, I consider, of such importance for the agricultural development of the tracts commanded by them that a great effort should be made by Government to complete them in the shortest possible time.

(3) *Crop improvement.* With the advent of irrigation facilities the introduction of new varieties of rice in a tract becomes a feasible and desirable proposition. Late heavy-yielding varieties can be grown in place of light-yielding early kinds. Much has been accomplished in this direction under Government tanks in Chhattisgarh within the last three or four years. Large quantities of selected seed of our best late and medium rices have been distributed from Government and private seed farms, and in many of the commanded villages the area under early rice is now very small. The introduction of one of our selected late rices in these newly irrigated tracts raises the acreage yield by from 350 to 400 lb. of grain per acre. Irrigation facilities, moreover, enable the cultivator to transplant these heavier-yielding varieties, in which case the yield is increased by from 700 to 800 lb. per acre as compared with the outturn of early rice sown broadcast. There are already some hundreds of thousands of acres of our selected *Gurmatia* and *Parewa* under cultivation, and the outturn of rice must have been increased thereby by many thousands of tons.

The irrigation of wheat adds on an average from 100 to 200 lb. to the outturn of that crop per acre ; groundnut is benefited to a still greater extent, as it does best on light porous soils. It has been conclusively proved that the latter crop, grown under irrigation, gives yields of over 1,000 lb. per acre on the lateritic (*bhata*) soil of Chhattisgarh which, before it was commanded by Government irrigation works, was regarded as being almost below the margin of cultivation. There is an area of approximately 75,000 acres of this class of soil which will be commanded by two of the large canal schemes already referred to and which could

within the next two or three years be utilized for the production of groundnut and sugarcane.

(4) The outturns of all the food crops are being increased *by introducing more prolific varieties and by seed selection.* It has been proved on the Raipur and Tharsa farms that the best of the wheats introduced give at least 60 lb. of grain per acre more than the varieties grown locally. The three selected *jowars* being distributed in the cotton tract compare still better with the varieties grown locally. The distribution of improved seed is being carried out in the Central Provinces as fast as circumstances will permit.

(5) *Manuring.* The yield of food crops could be very largely increased in a comparatively few years by judicious manuring. I look forward to the time when it will be possible for Government to finance the cultivator who wishes to purchase manures recommended by the Department on a much larger scale than is being done at present. The Co-operative Department will no doubt take up this work also, but until they are in a position to do so Government should, in order to introduce this and other agricultural improvements as soon as possible, give more in the way of *taccavi* to cultivators.

Everything possible should be done to increase the supply of cattle manure available for application to the land by instructing cultivators in better methods of conserving both the dry and liquid portions. The urine-earth system of conserving the urine is one which will, if adopted by all the cultivators of a village, double the value of the manure available in that village. The use both of green manures and of the more concentrated manures such as cakes and artificials should be demonstrated as soon as it has been proved by experiment that any one of them can be applied with profit. In the Central Provinces the use of cake as a cane manure has been introduced by the Department within the last few years, and has become a common practice among canegrowers in the Southern Circle. The new method of green-manuring rice with *san* (*Crotalaria juncea*) raised on the *rabi* area and applied to the rice area before transplanting is one by which the yield can be very largely increased at a very small cost. This new method of manuring, giving as it does a net profit of about Rs. 25 an acre when properly carried out, is a practice which has great future possibilities. To get cultivators to adopt it on a large scale will, however, require much patient demonstration work.

(6) *Double-cropping.* The double-cropping of rice lands is already widely practised in most districts where the soil is suitable for a second crop.

With the extension of irrigation the area that can be profitably double-cropped with pulses and wheat will be increased. At present the area so cropped varies from year to year, being dependent on the vagaries of the late rainfall. Given irrigation facilities, the cultivator will be largely independent of the rainfall. Under the large irrigation works being opened in the Central Provinces, we look forward to a considerable increase taking place in the area double-cropped.

(7) *Destruction of crops by wild animals.* The amount of damage done in the Central Provinces and Berar every year by wild animals to crops like rice, cane, groundnut, *jowar* and wheat is so great that in many villages they can be saved from total destruction only by employing watchers. The need of adopting remedial measures on a large scale is most urgent. Pigs which frequent the jungle and waste areas in the vicinity of villages account for most of the damage done. Their ravages can be checked to some extent by organizing pig-killing clubs, but it will not be possible to save these crops entirely, except by fencing them with patent pig-proof fencing. Good progress was being made in the Southern Circle of the Central Provinces in introducing this type of fence before the war broke out. I anticipate that when the war ends and prices again become normal, the introduction of this fencing will be one of our principal lines of work in some districts, but here again Government will have to be very generous in granting loans to enable cultivators to purchase it.

(8) *Increase in the area under food crops.* The area under food crops could be largely increased within a very few years, should economic conditions demand it. As a result of high prices since the war began, the area under wheat has already increased to a very large extent, and it will, without doubt, continue to increase at the expense of oil-seeds, for which the demand for the present has decreased owing to the difficulty of export. It can be increased very largely, too, in the Central Provinces at the expense of culturable fallow.

The rate at which the various improvements which I have outlined can be incorporated into the ordinary farm practice of the ryot depends upon circumstances which are not always under the control of the Department of Agriculture. At present the Department is handicapped by want of staff. In the lower ranks we require more Kamdars and more Agricultural Assistants : in the higher ranks we need more Divisional Superintendents and more Deputy Directors. Each province should, in my opinion, be divided up into comparatively small agricultural circles with a Deputy Director of Agriculture in charge of each. Each circle should have its own experimental seed and demonstration farms in order to enable the Deputy Director of Agriculture to test different

agricultural practices, to propagate the seed of strains which he has himself selected, and to demonstrate improvements which he desires to introduce. To effect improvements as expeditiously as possible he should give particular attention to the training of Kamdars for demonstration work, and to the practical training of the sons of land-holders on Government farms in agricultural improvements likely to give immediate results. In conclusion, I would add that as agriculture is, and will remain, our greatest industry and the backbone of finance in this country, the improvement thereof should be taken up in dead earnest. Though much has already been done by Government for the development of Indian agriculture and though practical results of very great economic value have already been attained, these I regard as but an earnest of much more brilliant results to follow.

(*c*)

(G. EVANS, M.A., *Deputy Director of Agriculture, Northern Circle.*)

The Northern Circle of the Central Provinces, of which I hold charge, consists of the nine northern districts in the Nerbudda and Jubbulpore Civil Divisions. The area comprises several distinct *rabi* tracts, wheat being the predominant crop averaging $2\frac{1}{2}$ million acres, while there are also considerable areas of *dhan* (paddy) and minor millets, and small but increasing areas of sugarcane.

IMPROVEMENT OF YIELD BY INTRODUCTION OF IMPROVED VARIETIES.

Wheat. In the Nerbudda Division the new wheats No. 13 and No. 85, which are pure line selections, have given increased average yields over *deshi* wheat of more than one maund per acre during the last three years, and are now grown on about 100,000 acres mainly in the Nerbudda Division. The wheat area of this division (excluding Nimar) is roughly 960,000 acres so that if No. 13 *Pissi* can completely displace *deshi* wheat, the grain increase per annum would represent 960,000 maunds or 30,714 tons.

In the Jubbulpore *Bundhwas* area which includes also parts of neighbouring districts, a straight selection, No. 88 now known as *Muriya*, has averaged on a series of field tests an increase of 150 lb. wheat per acre. The last two years (1915-16 and 1916-17) have been marked by absence of rust, and when this disease occurs, as it does about two years out of five, the increase in favour of No. 88 will be still more marked, as it possesses considerable power of rust-resistance. The average increase per acre over a series of nine years may, therefore, be

taken as two maunds, and the area to which it is particularly suited is about 400,000 acres. If this was all sown with No. 88 the annual increased outturn would be 800,000 mds. or 28,571 tons. The Vindhyan plateau comprising 650,000 acres has still to be tackled, but equally good results are promised for the Seoni District with its 275,000 acres of wheat and for the smaller areas irrigated by Government irrigation tanks where selected types are now being introduced.

The area under rice is relatively small, being only 490,000 acres, but good results are promised by substituting the new varieties, *Basmatia* No. 17 and *Dantasar*, which are now being introduced as rapidly as possible. An increased yield over the local *dhan* of at least three maunds per acre is indicated or a total of 52,500 tons on the whole area.

The present rates of propagation and methods employed.—Seed of improved varieties of wheat from the Government farms is disposed of entirely to certified seed farms. These are the home-farms of certain selected *malguzars* (zemindars) who grow the wheat under the direction of the Department, submit to an inspection of their crops and agree to carry out certain rules which ensure that the seed is kept pure. They renew a portion of their seed from the Government farms each year. They have the first call on any new variety raised by the Department, and the Department acts as an agent when required and arranges for the sale of their produce at remunerative prices.

The produce from these certified seed farms is all sold for seed as follows :—

(1) To Co-operative Societies through the agency of the Central Banks.

(2) To private persons who ask for improved seed.

(3) To their tenants on the *sawai bari* system.

The area under certified seed farms alone for the last six years is given below :—

	1911-12	1912-13	1913-14	1914-15	1915-16	1916-17
Area of seed farms in acres	1,085	2,971	4,070	4,721	5,084	6,408

The average outturn of wheat is not more than six times, and if this be taken as a standard it will give some idea as to the amount of seed which has been introduced in this period.

The inspection of the Department stops with the certified seed farms, but Co-operative Seed Societies are also generally supervised so far as the staff has time.

Possibilities of accelerating. This depends mainly on funds and staff. The latter in particular is very deficient. The system described above is also being applied on a smaller scale to the *dhan* and sugarcane crops.

Sanction has recently been obtained to start four more district seed farms of 150 acres each, and these will in due course have attached to them a group of "certified seed farms." Until these are opened, it has been found practically impossible to help several districts, as the demand for seed far exceeds the supply. We are aiming at establishing at least one big Government seed farm for each district, and there is no doubt that in some districts more than one will be required.

Increase by use of artificial fertilizers.

These are not promising with the exception of superphosphate on rice, which is still in the experimental stage but gives promise of good results. Nitrogenous artificials have not paid on the dry wheat crop as the rainfall is too uncertain a factor.

Improved cultural methods.

The iron plough which inverts a furrow and can be drawn by local bullocks undoubtedly increases the yield. The average outturn of wheat of the whole area of the Powarkhera farm has probably been increased by a maund per acre by using the Monsoon plough for the hot weather and early monsoon cultivation, as its use has resulted in a marked decrease in *kans* and other weeds. Steam or motor ploughs have not been tried as yet and, owing to the smallness of the fields and the difficulty of getting them about in the rains, are not likely to be useful.

Harvesting. Much loss at present is caused by harvesting operations. The Nerbudda reaper has proved satisfactory but is too expensive and too complicated for the majority of the agriculturists in these parts. Great loss is caused on the threshing floors annually. Winnowing machines are in great demand and several hundreds have been sold by now, but it has been found impossible to arrange for an adequate supply as the local workshops available are small and very inefficient. It seems likely that a small type of power thresher, preferably worked by a portable oil engine, will prove most satisfactory. Steam threshers will not have an extended use owing to the absence or extreme roughness of country roads.

CHAPTER V.

MADRAS.

(G. A. D. Stuart, I.C.S., *Director of Agriculture.*)

I take it that the emphasis is on the word *rapidly*, and consequently, so far as the Madras Presidency is concerned, the only food crop worth consideration in this connection is rice. Being an irrigated crop, the area annually cultivated, some 11 million acres, is fairly constant, and the return from better varieties and better manuring is *certain*. It is the only food crop in Madras in which there is any appreciable foreign trade. The annual outturn must be at least 6 million tons of husked rice, and of this some 140,000 tons are exported annually, mainly to Ceylon.

Improved varieties.

Work on the selection and breeding of improved varieties has been carried out by Mr. F. R. Parnell at the Paddy-Breeding Station at Coimbatore for the last three years, and a beginning has been made with testing the varieties in the district farms. But we have not yet arrived at the stage at which we can put out improved varieties into the districts on a large scale. We have first to test the superiority of the new varieties by careful comparative experiments. And it must be remembered that it is not only a question of gross yield. The variety must be suited to the special conditions of the tract, and in this connection the period of ripening is of great importance. Experience shows that this often alters when a variety is moved from one district to another. Each variety must therefore be specially tested in the tract for which it is designed. Granted a superior strain suitable to the tract, there would be no difficulty about distributing it. There has been a steady demand this year (1917) for the seed of a bulk selection of the main local paddy made at our agricultural station at Manganallur in the Tanjore delta. Seed sufficient to sow some 2,000 acres was sold in the current season. At an average rate of multiplication this would provide seed for 200,000 acres next year. The total area under paddy of all

varieties in the Tanjore delta, including second crop, is about a million acres. To multiply last year's work by five would not be impossible. We should be compelled to concentrate staff and temporarily abandon work in other districts. But the dislocation will be only temporary, as once a really good variety was widely distributed the work would be finished.

To establish a permanent system of distributing improved varieties as they are bred out will take time, but this will be our ultimate aim. It can be done by organizing co-operative seed unions on the lines of those which have recently been started for cotton in Tinnevelly. Once this system has been organized, any new strain of outstanding merit could be put out in three or four years.

The cost of distributing improved seed should be completely covered by the profits. Granted that the variety is worth distributing, the ryot will pay its full value.

Manures.

The spread of the use of artificial concentrated manures on paddy land is slow. This is mainly due to the fact that although they give a fair return on the capital spent, yet cattle manure will give a much higher return in proportion to the expenditure. The supplies of the latter cannot be increased and so fields go undermanured, because the landlords will not, and the tenants cannot, face the expenditure of using artificials, although the return may be certain. Much could be done, however, if Government were prepared to take legislative powers and act on a large scale to meet a grave emergency. The following scheme has been suggested by Mr. R. C. Wood, Principal, Agricultural College and Research Institute, Coimbatore :—

(*a*) Government to control the export of (1) oil cake, (2) bones, and buy up as much as was required at fixed rates.

The totals exported annually are as follows :—

	Quantity Tons	Value Lakhs
Bones	8,000	4½
Oil cake	58,000	50

This is mainly exported to Ceylon at present where it is used mostly for non-food crops.

The bones to be converted to super as far as the limited quantity of sulphuric acid allowed, and the rest ground to bonemeal, Government taking control of local manure factories.

(*b*) These manures to be supplied at cost price at depôts in a selected rice-growing area, *e.g.*, Periyār tract in Madura=167,000 acres; value to be recovered along with the land revenue after harvest. There is little doubt that the cultivator would take the manure readily so long as immediate payment was not asked for.

(*c*) The result would be a substantial increase in the total crop of the area, and Government might guarantee to purchase a proportion of the crop at a fixed price in order to provide against any local fall in price due to difficulties of moving the crop. Government would presumably require this grain for export.

Cultural improvements.

The main cultural improvement that has been advocated by the Madras Agricultural Department for rice is a reduction in seed-rate If universally adopted this would result in a saving of at least 100,000 tons of rice per annum, in seed alone, setting aside an increase in production of two or three times this amount. The reform is rapidly spreading, but it is not possible to suggest any method of expediting it to meet an emergency.

CHAPTER VI.

BURMA.

(T. Couper, M.A., I.C.S., *Director of Agriculture.*)

Present circumstances make it difficult to consider fairly ways and means of increasing food production in Burma. The immediate question is not how to grow more food, but how to sell what has been grown. Enormous stocks of paddy have accumulated for want of tonnage, and the market value has fallen to half of what it ordinarily is at this season. Nothing within the power of the Agricultural Department can counteract the effect of a collapse of price in depressing production.

The crops which are cultivated on a considerable scale and which are not primarily sources of food are cotton, tobacco, rubber and the *dhani* (*Nipa fruticans*) palm. It is improbable that these can be displaced by food crops. The area under cotton responds readily to fluctuations in value but the demand of the cotton trade is commonly said to be likely to remain in excess of the world's outturn; if so, high prices will prevent the substitution of a food crop for cotton. Though there is a large export of tobacco from Burma, the amount imported is larger still: the province consumes more than it produces. Most of the land under rubber and the *dhani* palm is not such as would grow food crops.

The problem has to be regarded from an imperial standpoint: the crops an increase in which is desired are crops that can be exported to Great Britain. The two crops grown on a large scale which are not exported are sesamum and fodder millet. There is little prospect that other foods can be substituted for these: the large import of sesamum seed shows the demand for oil to be greater than the supply, while the requirements of cattle-breeding necessitate the maintenance of a large fodder outturn.

No rapid increase in outturn can be expected from the introduction of improved varieties of seed on the 8,000,000 acres under paddy in Lower Burma. The Department has aimed at raising the income of the cultivator by providing him with pure seed of better quality rather than with

more prolific varieties : its object has been to eliminate red colour and to produce pearly grain of suitable size and shape which will give when milled a large outturn of whole white rice and for which in consequence the mills will pay higher.[1]

The selected variety of paddy which is being distributed in most of the irrigated districts in Upper Burma yields, when grown under supervision on the departmental farm, 20 per cent. more than the unimproved kinds grown by the cultivator. In his hands the increase is less and it will be safe to place it at 10 per cent. The improved variety was grown on 35 acres in 1914, on 350 acres in 1915, on 2,000 acres in 1916, while this year (1917) the area is estimated at 9,000 acres.[2] The district with the largest area under assured irrigation will not grow this paddy ; the mills in it work largely for local consumption and the improved variety, though well suited for export to Europe, is not considered locally a good eating rice. At an outside calculation the area on which the improved seed could be cultivated cannot be put at more than 500,000 acres and the increase in food at more than 20,000 tons of rice. To get the seed introduced rapidly into the six districts over which the 500,000 acres are spread three or four seed farms in each district would have to be opened. Once he saw the improved variety grown successfully under local conditions, the cultivator would probably be quick to multiply it.

Increase in feeding value is as important as increased outturn. It has often been asserted that the polishing in the mills reduces the value of rice as food. In the event of shortage it might be necessary to polish less, to sacrifice appearance and to adopt a different method of cooking so as to obtain a more nutritious food.[3]

Except cotton the Department has no other improved varieties ready or nearly ready for distribution. In pulses little assistance is wanted : the rise in the price of the so-called Burma bean has brought about in the past year an increase of 110,000 acres, or 60 per cent., in the area under cultivation. Selection in cotton has so far been made with a view to lint outturn and not to yield of cake or oil.

Chemical analysis has shown that many of the Lower Burma paddy soils are deficient in available plant-food. Experiment on the Hmawbi farm has proved that an increase in yield extending up to 77 per cent. can be obtained by the use in moderate quantity of artificial manures.[1] But at present rates the value of the increase is little, if at all, greater than the cost of the manures. This is true even of bonemeal, which

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[1] Reports of the Hmawbi Agricultural Station by Mr. A. McKerral.

[2] Report of the Mandalay Agricultural Station for 1916-17 by Messrs. Thompstone and Sawyer.

[3] The Chemical Composition of Paddy Mill Products by Messrs. Warth and Darabsett.

is crushed locally. If, after the war, paddy rises and manures decline in price, then it may be possible by demonstration to induce the cultivator to increase his outturn by their use. But the price is sure to remain an obstacle to their extended application. Co-operative societies, by advances, and Government, by agricultural loans, cannot make it possible for the cultivator in general to purchase manures, and it would seem that all the Agricultural Department can do, except demonstration, is to bring to the notice of private enterprise the need which exists and the profit to be gained from ministering to it.

The proper conservation of farmyard manure, the application of paddy husk whether burnt or unburnt, the ploughing in of stubble on certain soils in place of burning it, the right quantity of seed in a nursery, the correct spacing of paddy seedlings, the right number to plant together, will all in the long run increase the outturn, once the cultivator has as the result of demonstration grasped their advantages. But no rapid progress can be expected ; in especial, tenants holding on a yearly lease, in whose hands is the cultivation of approximately 3,000,000 acres in Lower Burma, will be slow to avail themselves of methods of manuring which leave the land more fertile than they receive it.

The area annually fallowed in the dry zone of Upper Burma is approximately 3,000,000 acres. The cause is not so much the inadequate amount as the uneven distribution of the rainfall. Though it is only once in four or five years that a fair paddy harvest is reaped and though dry crops are now much more valuable than they were, the cultivator is still in the habit of trying to grow paddy and is forced for want of water to leave much of his land unworked. Another consequence of the uneven rain is the necessity of insuring by growing a multiplicity of crops ; the fall that suits one crop ruins another and so the cultivator occupies a large area and puts down such crops and leaves untilled such soils as the rainfall of the year dictates.

It has been suggested that the Agricultural Department might show the cultivator two ways of reducing the fallow area. One is the conservation of the rain by soil mulching, by growing of hedges to counteract the drying winds, and by the other methods of so-called dry farming. The second is the introduction of steam-ploughing to break up the puddled layers of the paddy fields, followed by demonstration on a large scale of how dry crops may profitably be substituted for paddy. Whatever the merits of these suggestions, time is required for their working, and no rapid increase in food can be hoped for in this way.

Survey of the action within its power seems, therefore, to show that the Department can in Burma do little to bring about rapidly a greater

outturn of food. What it can do appears of little importance in comparison with the stimulus which would be afforded by guarantees of minimum prices, compulsion to grow certain crops, diversion of food exports from foreign countries to Great Britain, and other executive or legislative measures.

Statistics of cultivation in Burma in 1916-17.

	Acres
Occupied area	18,350,000
Fallowed area	3,900,000

Area under—

	Acres		Acres
Paddy	10,600,000	Plantains	120,000
Sesamum	1,215,000	Condiments (chillies, etc.)	100,000
Millets	820,000	Tobacco	80,000
Pulses	650,000	Gram	65,000
Gardens	330,000	Wheat	45,000
Groundnut	260,000	Sugarcane	18,000
Cotton	220,000	*Dhani*	61,000
Maize	170,000	Rubber	59,000

Exports (Inland and Foreign) of certain foodstuffs in 1916-17.

Rice (husked)	41,220,963 cwt.
Pulses	1,642,028 cwt.
Groundnut oil	614,230 gallons
Groundnut cake	545,000 cwt.
Cotton-seed oil	74,000 gallons
Cotton cake	63,000 cwt.
Chillies	2,096,853 lb.

Imports (Inland and Foreign) of certain foodstuffs in 1916-17.

Betelnut	39,288,277 lb.
Sugar excluding molasses, confectionery and saccharin.	301,489 cwt.
Wheat flour	261,861 cwt.
Sesamum seeds	240,517 cwt.
Fruit and vegetables	Rs. 3,310,690 worth.
Tobacco unmanufactured	17,442,832 lb.

Analysis of—

	(i) Polished rice	(ii) Rice meal			
Starch	80 per cent.	53½ per cent.	(iii) 100 lb. husked rice.	55 lb. polished rice.	0·59 lb. nitrogen. 0·14 lb. phosphoric acid.
Proteid	6½ per cent.	11½ per cent.			
Oil	½ per cent.	13½ per cent.		11 lb. meal.	0·22 lb. nitrogen. 0·41 lb. phosphoric acid.
Ash	½ per cent.	9 per cent.			

CHAPTER VII.

BOMBAY.

(The Hon'ble Mr. G. F. Keatinge, C.I.E., I.C.S., *Director of Agriculture.*)

The question is, how can the Agricultural Departments in India take measures to provide for a large outturn of foodstuffs in the immediate future to meet the probable world shortage of foodstuffs.

So far as this Presidency is concerned, the outstanding fact is that a very large area of cotton and oil-seeds is sown every year, and that owing to the very high price of cotton during the past season (1917-18), which continues to the present time, every cultivator will aim at sowing the maximum amount of cotton during the coming season which means a corresponding decrease in food grains. If it is really desired to increase the stock of food grains, the most obviously effective method to do so is to enact immediately that no cultivator shall sow more than a certain proportion of his holding to non-food crops. A second method, which may be adopted in cases where Government control the irrigation facilities, is to issue irrigation water only for food crops. It has been suggested that by issuing superior seed or by taking other methods of direct agricultural improvement some immediate results can be obtained in the direction of increasing the outturns of food grains. I can only say that in this Presidency I do not think that anything material of this kind can be done. The land which is fit for cultivation is already being cultivated as far as the resources of the people will permit, and, while the efforts of the Agricultural Department to secure better cultivation, the use of better seed, and the application of more and better manure, all tend in this direction and are slowly bearing fruit, there is no short cut to success of this kind which we can take. If there were we should have taken it long ago. There are a great number of varieties of *jowar* (*Andropogon Sorghum*), *bajri* (*Pennisetum typhoideum*), rice and wheat sown in the different tracts which are proved by long experience to be suited to those tracts, and we have no superior strain which we can hand out wholesale to the people and which can

be expected to increase the crops. Even if we had such strains, we have not the staff or the organization to do work of this kind on a scale which would produce results in the immediate future, nor could we immediately secure the acceptance of our views by the cultivators concerned. Further we cannot effect any rapid change in the defective organization or the standard of work on the part of the cultivators. I, therefore, think that in this Presidency the only effective steps are those which I mentioned at the beginning, *viz.*, to limit the area of non-food crops on each holding, and to issue irrigation water mainly for food crops.

BIHAR AND ORISSA.

(G. MILNE, M.A., I.C.S., *Director of Agriculture.*)

On receipt of the note recorded by Mr. Milligan, officiating Director of Agriculture, Bengal, regarding a proposed discussion at the Board of Agriculture on the subject of an increase of the outturn of food crops in India in view of demands likely to be occasioned by the continuation of the war, I consulted the Deputy Directors of Agriculture in Bihar and Orissa but received no suggestions of a practical nature, and upon a consideration of the whole situation have decided that the continuance and expansion of the ordinary activities of the Department will best meet the situation. At present these consist, so far as cereals are concerned, in an extension of the area under Pusa wheat, mostly No. 12. In addition groundnut is being introduced on a large scale in Orissa and also in Bhagalpur and Patna Circles. *Indrasail* paddy has also been tried with much success during the past season and there is scope for its introduction on a large scale next year. We have now got to the stage in this province when we are able to think in hundreds of maunds instead of in tens, and I am glad to say that I have received a substantial allotment of Rs. 37,500 in the coming year's (1918-19) budget for the purchase of seed, so that I anticipate very considerable progress in the introduction of improved varieties.

ASSAM.

(J. MCSWINEY, M.A., I.C.S., *Director of Land Records and Agriculture.*)

I have discussed the question at length with Meggitt and McKay and am afraid that in Assam we can do little as a Department. Our

main food crops are rice and tea and with the latter we are not directly concerned. The province in normal years now exports paddy, mainly from the Surma Valley, while the Assam or Brahmaputra Valley still has to import rice to feed the tea garden population. The use of fertilizers or improvements in cultural methods are out of the question here for at least another generation. We are trying to breed pure lines of rice, but, without the help of the Bengal Botanist and in the absence of a Botanist of our own, I am afraid that rapid results are unlikely.

We are growing ourselves about 500 acres of cane which we hope will be made into white sugar. If this experiment succeeds, we hope to see some white sugar factories in the province, but not until machinery is available after the war.

I am writing accordingly to let you know that we can produce no scheme.

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Agricultural Research Institute, Pusa

SOIL DRAINAGE

BY

R. G. ALLAN, M.A.,
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SOIL DRAINAGE

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Introduction.

THIS paper covers a subject the principles and practice of which will be fairly common knowledge to any one who has had any practical experience in estate and field drainage in England. The work in progress on the Agricultural College Farm at Nagpur has so often proved of interest to visitors and so frequently been the cause of subsequent letters on their part, or on the part of others enquiring for details, that the necessity of a paper on the subject seems well-founded.

The advent of the monsoon and the enormous interest taken in the arrival and plentitude of the rains—undoubtedly a factor of absolutely essential importance in Indian farming—have led to a popular feeling that rain is all that really matters.

In the writer's experience, however, this is very far indeed from being the case, at any rate over large areas of the Central Provinces and probably so elsewhere in India. Both the plants growing in the soil and many of the lower biological forms of life inhabiting the soil, on which the plants' growth depends, demand both water and air—not only water and air but fresh water and fresh air—for their existence and growth.

In many soils, in particular during the earlier part of the monsoon downpour, the former is in excess and the latter chiefly remarkable by its absence or great deficiency. As the soil pores are chocked with water, the passage of this water downwards is normally very slow, and there is thus a considerable stagnation of water in the soil which prevents the necessary entry of air. This takes place at a period of the plant's growth when it is young, delicate, and particularly susceptible to unfavourable conditions. Not only is the plant root-system practically suffocated by drowning but certain processes, such as nitrification, almost cease. In short, the crop shows all the evidence of being waterlogged. Plants checked in their growth when young rarely, if ever, recover, while the effort on the part of such as survive this bad condition to

avoid the excess of water below the immediate surface layer, tends to the development of a number of shallow surface-feeding roots with the result that later the plant is not in a position to strike down when the excess water has eventually percolated.

In addition, the various processes of tillage are either restricted or suspended. For example, deep ploughing as preparatory for cotton or *kharif* (monsoon) crops in general, unless given for the purpose of the extermination of *kans* (*Saccharum spontaneum*) or *hariali* (*Cynodon dactylon*), is a process of very doubtful value in many areas and fields in the cotton tract. The objection to the practice lies partly in the delay which arises in getting the cotton sown and partly in the increased water-holding capacity and subsequently intensified tendency to water-logging which ensues. Yet, if conditions exist which permit of the removal of this water from the immediate root-zone, early sowing, really done to allow of the establishment of the plant before the heavy July-August rains, is not essential and the waterlogging effect does not exist. Ploughing before cotton, in the majority of cases, cannot be advised as being better than the country surface *bakhar* work, except in areas of low rainfall or on fields in which either position or subsoil permits of a satisfactory soil drainage. Again, intercultivation, of which the primary objects in the monsoon are weed destruction and the breaking of hard surfaces to allow of aeration and the adequate production of a soil mulch later in the year, is prevented or reduced to a minimum. Weeds, hard surfaces, and inferior mulches become more and more common features of cotton cultivation as one travels from the areas of comparatively light rainfalls to those in which the rain of July and August is more persistent and as one passes from the higher and better drained fields under cotton to those in lower positions where the water received for disposal by the soil is greater and where the soil is deeper and heavier.

Observations in many parts of the cotton and principal *kharif* growing areas and on the College Farm (which is situated in one of the wettest sections of the cotton tract) have led the writer to the belief that lack of adequate drainage is one of the primary factors affecting the output of cotton over thousands of acres now under this crop. The great increase in the value of cotton has tended to its expansion to fields which are apt to dry out too early for the highest yields at one extreme, and, at the other, on to fields which are definitely too wet in July and August. Even in fields which have grown cotton for a very long period of their history in many places in the eastern section of the cotton belt, the soil climate is usually too wet for the best returns. Respectable yields, when compared with those commoner in

Berar, are only got after distinctly heavy manuring and an exceptionally favourable distribution of the July-August rainfall. Again, there are hundreds of fields which might, on the whole, be classed as suitable for fair production without direct assistance, which contain lower-lying hollows or corners in which the only choices to the grower are a very poor outturn or the relegation of the patch to the growth of a second-rate wheat or gram crop—second rate as, on account of its isolation, smallness, and wetness in the rains, the cultivation given is inferior and not on the level of that given to true *rabi* (winter crop) fields.

Poor outturns, lack of effect of the manure applied, and inferior tillage appeared to be the direct outcome not of want of water but of excess of water and resulted in the production, in the classes of soil usually carrying cotton, *i.e.*, loams and clay loams, of a soil climate which was detrimental to the growth of semi-arid tropical crops like cotton and *juar* (*Andropogon Sorghum*) and to the development of the lower biological forms of life on which much depends. Experimental work in underdrainage and surface drains was thus started on various fields over the College Farm, till at present there are about 10 or 11 underground systems, draining areas ranging from a fraction of an acre to 3—4 acres in extent. All these have not been completely successful, but in such as have partly failed in their object the reason of failure has been identified. The majority have however fulfilled every expectation. In one or two cases crops of cotton are now growing on areas which were practically useless till action was taken, and on others the cotton crops growing are earlier, bigger, and considerably more prolific than the same crops on the best placed true cotton fields of the farm after similar manurial treatment. These results are the outcome of a better environment and better opportunities of cultivation in the monsoon.

The recent opening up of cotton cultivation in Chhattisgarh has but emphasized the general observations on the growth of cotton on the College Farm—that a free drainage in the monsoon and aeration are essential factors of success. The *bhata* soil of Chhattisgarh has little to recommend it from the general standpoint of a good soil; it is poor, stony, and infertile. Given, however, small dressings of manure, it responds immediately and the growth of cotton and other crops in the monsoon is steady, rapid, and unchecked. This arises purely from a natural free drainage, as the actual rainfall is some 20″ in excess of the wettest part of the cotton tract proper. Some recent partial trials of cotton cultivation on some of the heavier soil of the same area, with the assistance of moderately deep surface-drains, have again indicated that cotton can grow in even these soils in wet districts, if attention is paid to getting rid, sufficiently rapidly, of the gravitationed water from the soil.

The removal of water on the College Farm has been attempted by the direct use of under-drains, by the shaping of the field surface into gentle undulations like that noticeable on old pasture land on heavy soil in many counties in England, by a system of contour ditches which imply a partial surface-drainage flow succeeded by a suction action on the water in the neighbourhood of the ditches and by the protection of fields from water received by surface flow from higher fields. The writer has, however, principally developed the first named, in the belief that the initial cost though greater is more than compensated for by the increased cultivable area, the greater efficiency of the drainage, the absence of weeds (the usual accompaniment of any open drainage system), and the removal of the heavy annual cost of ditch upkeep invariable with open drains in the wetter areas on the black cotton soil.

Field Protection.

Before dealing with under-drainage, it may be as well briefly to outline the work and results of the other three methods adopted to control the monsoon water in the soil. Field protection is not drainage in the sense that there is no removal of water received from the neighbourhood of the plant and there is no effort to reduce the water received by natural rainfall. Many fields, however, in the undulating conditions of the black cotton country are called on to deal with and dispose of by percolation a good deal more water than actually falls on the surface in the form of rain. Considerable relief can thus be given a field by controlling the surface flow from upper areas. This control often allows such fields to be sown in *kharif* crops, whereas before treatment it was impossible to cultivate them. Field protection is arrived at by the construction of *bunds* (embankments) and suitable water carriers. Any form of field protection demands both. *Bunds* which check erosion and possibly protect the field below them are not infrequently to be seen unaccompanied by any means of controlled water-removal. Such systems are definitely faulty, as the prevention of erosion and damage to the lower fields is gained at the expense of waterlogging in fields higher up. Any system of field protection must be designed so as to allow of the removal of the water held up by the protective checks.

The map attached illustrates the condition before and after protective measures were started on one of the College Farm fields. (Fig. 1.)

Originally F received the flow water of all fields, while C got all the water of A and part of that of B and E. An examination of the map will show that these two fields are now entirely protected. The area C was at first practically a water-cut valley between the higher parts

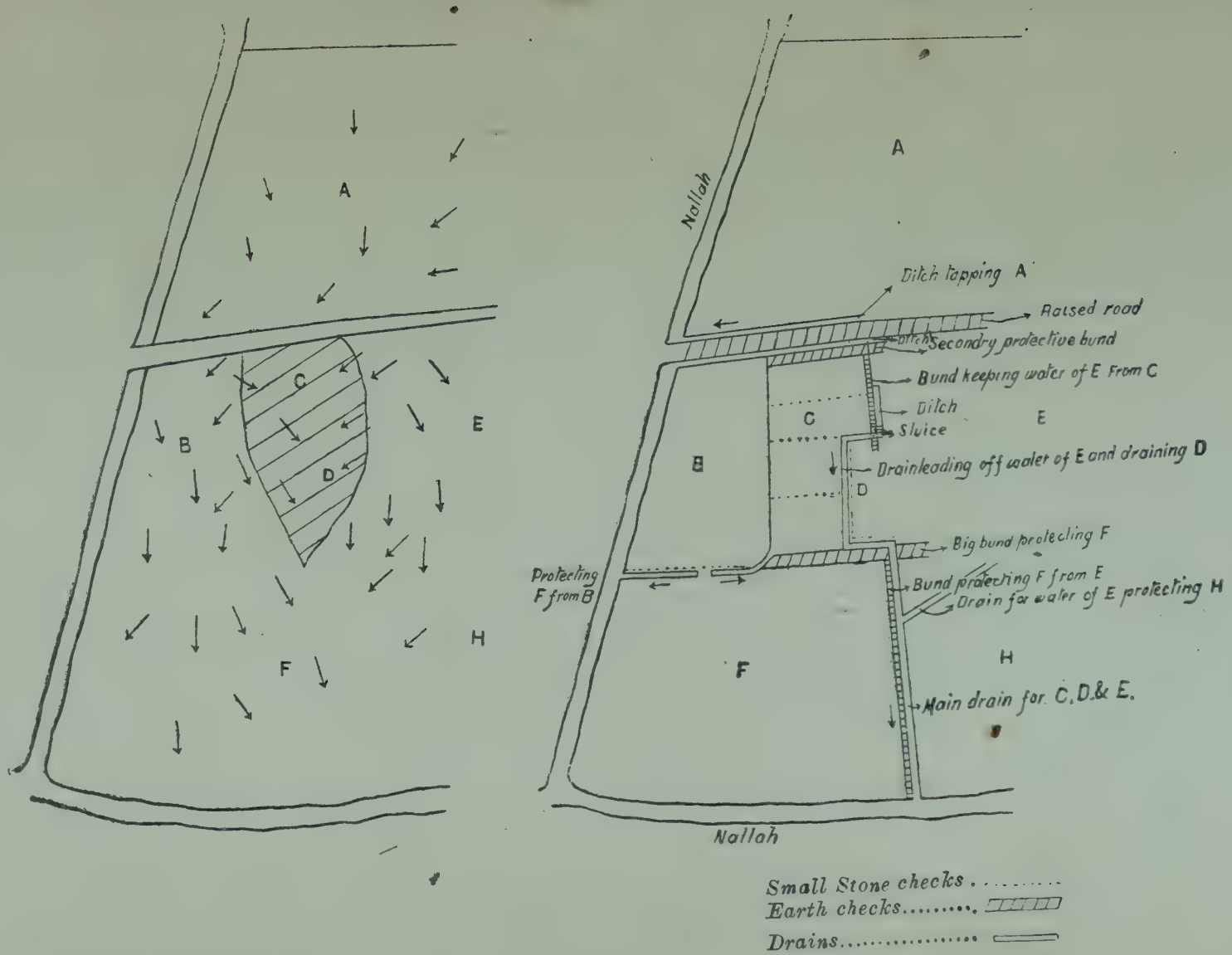

A
B
C
D
E
F
H
Nallah
Ditch tapping A
Raised road
Ditch
Secondry protective bund
Bund keeping water of E From C
Ditch
Sluice
Drainleading off water of E and draining D
Big bund protecting F
Protecting F from B
Bund protecting F from E
Drain for water of E protecting H
Main drain for C.D.& E.
Nallah
Small Stone checks . . . . . .
Earth checks . . . . . .
Drains . . . . . .

FIG. 1.

of E and B. Large parts of F are now capable of growing good fodder in the monsoon and C is fully under cultivation. The upper checks are now nearly flat and carry *kharif* crops.

Ridge and Furrow.

This adaptation of an old system, common on heavy soils before the introduction of under-drainage in England, has proved quite effective. The field under treatment is ploughed into lands with alternating gathered ridges and open furrows. In practice, the final condition of the field is not reached for 2-3 years, but a very considerable difference may be produced by completing two ploughings of like character over the same area. In case any one may not understand what is intended the plan and section of a field so treated are given below.

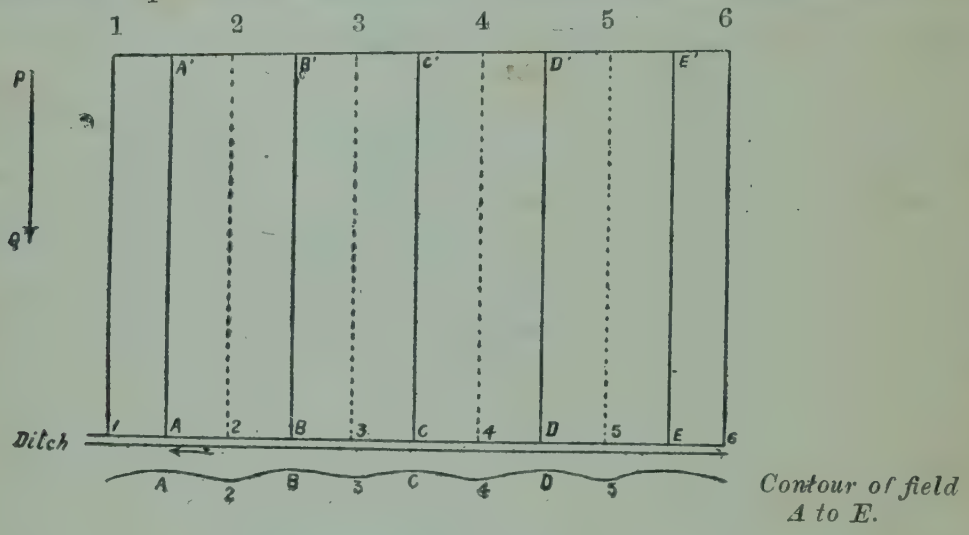


FIG. 2.

Assuming the mould board is on the right, the plough is sent up the line A—A′, is turned to the right at A′ and returns to A, thus throwing the soil together along A—A′. Ploughing is continued round A—A′ till 1—1 and 2—2 are reached when the plough is transferred to B—B′, and the same process continued till the plough works out to 2—2 and 3—3, and so on. At the lines A—A′, B—B′, etc., we have raised soil, while along 2—2, 3—3, etc., we have wide open furrows. Water received on the area A—A′ and B—B′ drains down two short slopes without effecting erosion to the line 2—2 which acts as controlled water channel and removes the water to a drain along the line ABCD.

The best distance between 2 and 3 will vary with the texture of the soil. On the clay loam character of the black soil we have found 30 feet satisfactory. Some attention must be given to the slope of the field in deciding the direction in which the lands are to be ploughed. If the slope in direction PQ above is at all steep, the lands should be put

at an angle to the main slope. The ultimate gradient of 2—2, 3—3, whether down the direct slope of the field or at an angle to this, should probably not exceed 1 in 300. It is advisable to place a few short pegs, roughly interwoven with cotton or *san* (*Crotalaria juncea*) stalks or grass, at the point where 2-3-4, etc., reach the main drain. If the two above are attended to, little or no loss of soil occurs, while the general growth over the field is considerably improved and a reduction is made in the area usually covered by the meandering streams so commonly seen.

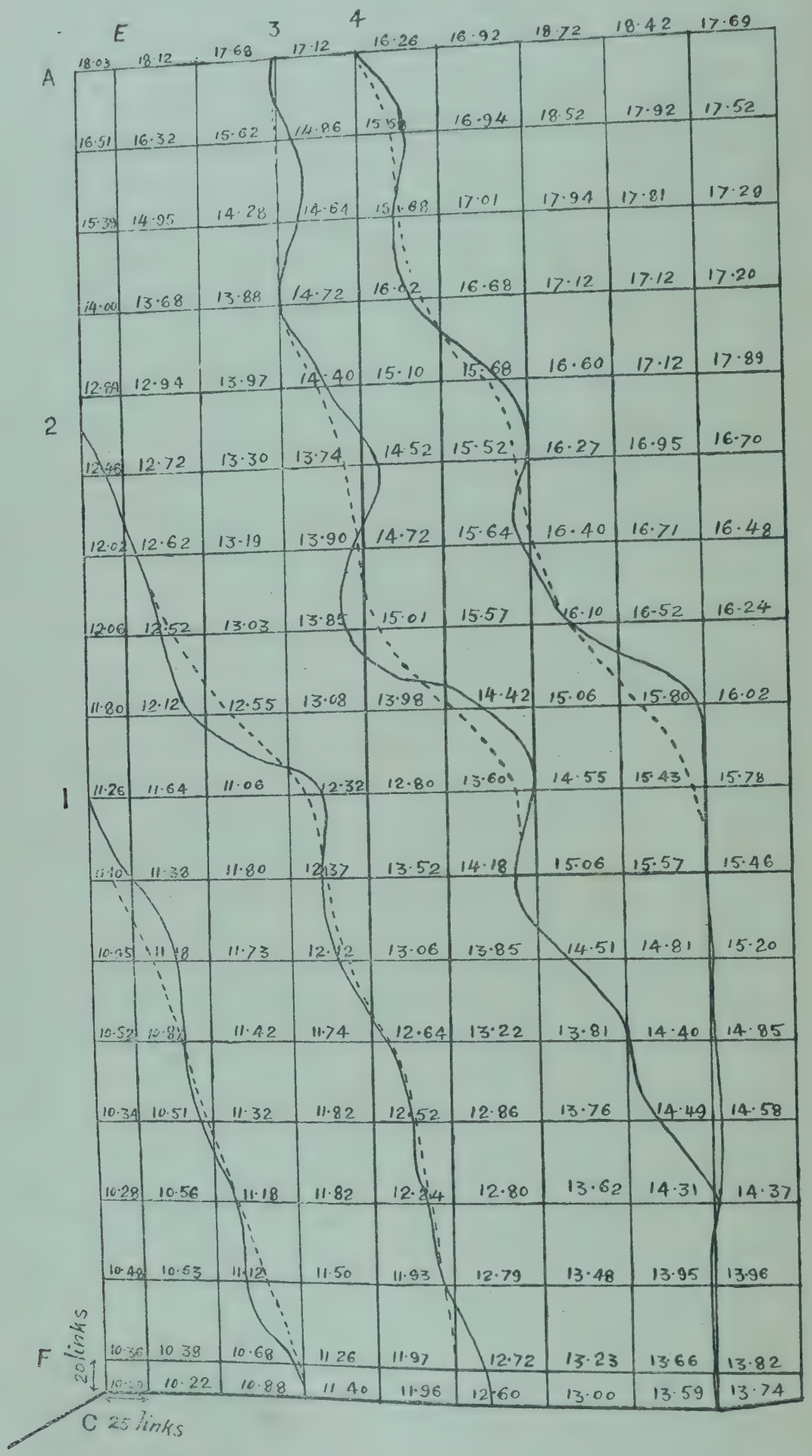
Contour Open Drains.

When working with under-drains on the farm, it was noted that certain fields responded badly to under-drainage or required so close a placing of these drains as to become too expensive for common practice. This was the case, in particular, on fields in which the subsoil consisted of *chopan*, a stiff yellow clay. As the areas covered with this class of soil are of a gentle undulating character, it was decided to use open ditches. These ditches were aligned approximately along contour lines, small hollows, which might cause the true contour channel to be too winding, being filled in with earth removed from the ditches. A contour survey was first made and the lines of the proposed ditches marked out on the map. The field was then visited and staked out and subsequently examined with a view to straightening out the ditch lines. The ditches were then dug 20″-22″ deep, about 1′ 3″ wide at the bottom, and with sides at about 60° slope. Along the upper margin of each ditch about 1′ from the edge was placed a small check of boulders about 6″-8″ high, surfaced with a little earth from the ditch.

The plan of one of the areas drained in this fashion is given on p. 8 (Fig. 3).

The action during rain is a surface flow over the area bunded by two contour channels towards the lower channel and its boulder check. At this point the water is close enough to the drain for its suction-action to have effect and the water is drawn through the soil below the check into the drain, and subsequently flows away down the drain, which is given a slight fall of about 1 in 400 to the main ditch on the field boundary. The writer has termed this system "contour open drains" as they appear to be more likely to be of value when laid on fields which possess a fall. On level or nearly level lands, the surface flow would be very slow, and in consequence the drainage-ditches to be effective would have to be sufficiently close to provide a suction effect. This would entail either very deep drains or too many, with consequent loss of area, as well as difficulty of tillage and excessive cost of up-keep. When first set out, contour surface drains require a good deal of attention on account of fall of soil and the like, till the angle of settlement is finally

CONTOUR DRAIN PLAN ON FIELD 47.



Whole lines = Original contour position of ditches.
Dotted lines = Final position of ditch after filling hollows with earth.
Area of checks = 50½ × 50 links.
Area = 2½ acres.

FIG. 3.

reached. They require cleaning annually in order to keep them in a state of efficiency. In draining stiff soils, they appear to be cheaper and as effective as under-drains. The cost of the system given in the plan was :—

	Rs.
Digging and construction of channels and bunds	29
Boulders 900 cubic ft.	45
	74

or about Rs. 30 per acre

Under-Drainage.

A study of this method of correcting the water-content of soils growing crops in the monsoon has now been in practice for 7 or 8 years on the College Farm and some ten systems are in working order. Of these only one is a partial failure. Though it was not till recently that land was available on which a close experimental study was possible, results obtained on the areas selected for improvement have been so marked, that the advantages gained by the treatment have been obvious. It is hoped however that it will be possible in the near future to make a closer study of the root-development, loss of salts, and the like. In this paper it is only intended that a brief description of the results obtained and the methods employed should be given.

With reference to the former the following are among the larger systems which have been in work for 3 years or longer.

Field 8. Part of sewage farm. Soil, a loam developing to a stiffish clay loam at about $1\frac{1}{2}'$ below surface ; area, fairly high-lying. This area was under-drained to study the effect on *juar*, which had given indications of being an unsuitable crop for a sewage farm in the rains on this class of soil. It was under comparison with a similarly sown and cultivated, but undrained, area on the farm.

The returns of *juar* fodder are recorded below :—

Year	Drained lb.	Undrained lb.
1914-15	11,609	7,833
1915-16	20,506	15,290
1916-17	22,109	20,450

In spite of being naturally well placed as regards its drainage, the effects of under-drainage, particularly in the early years before the soil had got enriched, is evident.

Field 44. This field is one generally allotted to a *kharif* crop. It has, however, at one corner a portion which was totally unsuited to this

class of cropping, as it is low-lying and thus receives the surface flow of the best part of 15 acres. The soil varied from a free clay loam to a clay loam. The following history yields an indication of the effect of under-drainage on this block of about 2 acres.

1909-10. *Tur* (*Cajanus indicus*) was almost a failure over the area owing to excess water.

1910-11. *Juar*; a year of light rainfall; the crop was about the same as in the higher areas of the same field.

1911-12. Gram. Net returns about Rs. 5 per acre.

1912-13. Wheat. Net returns about Rs. 8-6 per acre.

Under-drainage.

1913-14. Not a very good cotton year. Return of cotton over under-drained area 355 lb. per acre as against 230 lb. on the balance of the field.

1914-15. Fodder. Yield nearly twice that of the rest of the field per acre. Crop almost 18,000 lb. dry fodder per acre.

1915-16. *Juar* for grain. Yield of grain per acre of drained land, 910 lb.; and from the best acre of the balance of the field 747 lb.; fodder not weighed.

1916-17. A poor cotton crop due to an excessive and protracted monsoon. Average, over farm, only about 6 annas of normal. Outturn of drained area was not much above rest of field due to the fact that, as ripening is about 3 weeks earlier on this area, the bad effects of the late rain were more marked.

1917-18. In this year the rain was excessive in July. The only part of the field which could be got under cultivation and sown was the drained area. The rest of the field was fallow. The cotton crop grew well in spite of rain, but the yield was seriously reduced by the continuation of the rains to mid-October. The outturn 163 lb. compared favourably with the poor average over the farm. The estimated average net profit per acre over the first period was between 9 and 10 rupees. The average net profit over the balance of the period when under-drained was Rs. 46 in spite of two years in which causes, entirely apart from the soil-moisture, markedly lowered the yield.

Field 23. A most unsatisfactory field. It was usually badly waterlogged over two-thirds of its area in the monsoon and dried too rapidly in the cold weather to allow of wheat or gram. Under-drainage

showed a layer of typical black soil to a depth of 18″ to 2′. Below this lay a bed of coarse sand about 3″-4″ thick at the lower end and deepening as one passed up the field. This in its turn was underlain by a stiff clay which possessed a natural dip from the lower end of the field, thus allowing the increased depth of sand as one moved up the field. The *chopan* (clay) produced a semi-lake-like condition during the monsoon. The introduction of under-drains at once corrected the defect and the field now grows among the best cotton and fodder crops of the farm area.

Field 47. A soil of very variable character consisting of loam near the surface, passing at the upper end to a sandy murrum, and in the lower parts to a stiff *chopan* subsoil. In this field the under-drainage was only successful in parts. Examination showed that failure was due to a faulty laying of the pipes as regards depth (due to much surface irregularity) and distance between lines. The more recently laid systems are all working excellently and further extensions have been continued this year which have enabled blocks of more accurately experimental character to be taken in, thus allowing of a closer comparison of results with those on undrained blocks.

Methods employed.

Materials. The pipes used are home made. They are, practically speaking, the ordinary wheel tile before cutting for roofing purposes, *i.e.*, baked whole instead of halved. The shape of the tile is thus usually slightly conical, though more recently the potter has got into the habit of making them more cylindrical, so that the end of smaller diameter just fits into the end of wider diameter, thus reducing waste by unnecessary over-lap. The tiles passed for use are those free of cracks and possessed of a clear ringing note when tapped, and, on laying, three are estimated to each two feet of drain. The cost, all charges included, works out at about Rs. 19 per 1,000 minor drains and about Rs. 30 per 1,000 main. The minor drains are about $2\frac{3}{4}$″ diameter at one end and about $3\frac{3}{4}$″ diameter at the other, while the mains are $3\frac{3}{4}$″ and $4\frac{1}{2}$″ respectively. The main size is only used if the system of minors feeding it is extensive. Allowing for the large quantity of water which has to be drained out during certain periods of the monsoon, a main would probably be necessary in any area over two acres; but the minimum size of main for various areas has not been worked out, though there is evidence to indicate that a main of a certain size will not deal with the same area of under-drained land as is usually estimated in England. In all systems the minors are arranged to deliver on the top of the main. Minors intended for a junction are closed at the smaller end and have a

hole cut in the side, which fits over a special main pipe made with a hole of similar diameter on its side in addition to two at each end. (Fig. 4.)

TYPES OF UNDER-DRAIN TILES

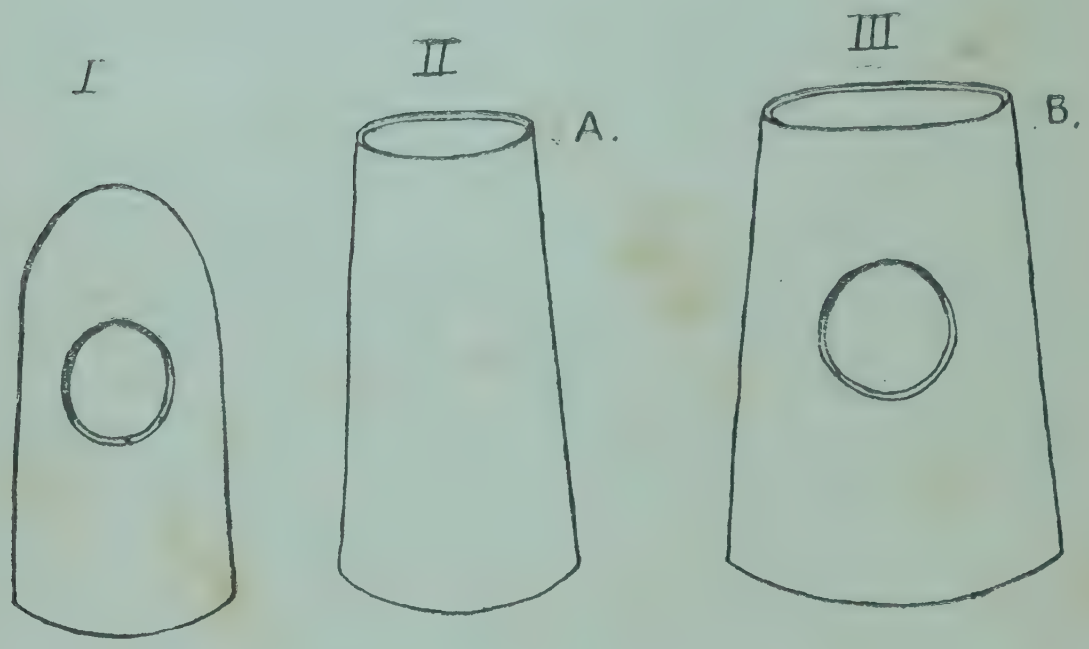


FIG. 4.

I. Minor junction tile.
II. Ordinary minor tile, 9″ long and 3″ diameter at A.
III. Main tile at junction of a minor, 9″ long and about $3\frac{3}{4}$″ at B.

The process. It may be mentioned here that nothing very difficult has hitherto been undertaken and, further, the majority of the areas which best respond to treatment are those which are low-lying. In the black cotton area such spots are generally reasonably near a *nullah* and so there is not much difficulty in finding a suitable outlet. The area to be under-drained is examined. Frequently the eye can tell which way the minors and mains should run. If however the area is flat or almost so, a check contour is taken. After a chain survey of the area, a suitable position for the outlet of the system is selected. If the general fall is obvious the position of the main and minors is pegged out on the field and the elevations along the future lines taken. If not directly obvious, the position of the drains is worked out on the check contour plan, and then pegged out on the field. The elevations along these lines may be deducted from the contour check or, when accurate work is essential or the ground irregular, a fresh set of elevations may be made along the field lines.

Distance and depth of minors. These two are closely associated and depend principally on the soil to be drained. In stiff soils and in draining grass areas the drains approach each other and the depth is reduced. As the soil becomes lighter a wider spacing and a greater depth may be allowed. Generally speaking 2′ 6″ represents about the minimum depth and 3′ 3″ the maximum on any classes of soil drained on the College Farm—the lightest of which is free clay loam with some *kankar*. The closest placing yet adopted was 18″. This was in a stiff clay soil. Though the drains appear to work freely, even at this distance, on the stiff soil mentioned, the central area is only just influenced by the drain. On very stiff soils it is thus probable that a surface system like No. 3 is more economical, especially if the area has any fall from one drain line to another. On the black soil proper, a stiff clay loam, the drains are effective at 21′—23′ apart with a depth of 2′ 8″ (average). A number of areas on the farm are slightly less heavy than typical black soil and in these 24′—27′ have been found satisfactory with a depth of 2′ 10″ (average). It should be noted that one has often, due to surface undulation, to exceed the average and pass above 3′, but, given that the distance is correct, care should be taken not to let the depth be less than 2′ 6″, if it is possible to avoid it.

Fall of minors. In several areas the fall of these has been about 1—100 though falls of 1—150 have been used satisfactorily. It is probable that lower falls can be utilized ; but, allowing for the amount of water which at times has to be disposed of, the writer is of the opinion that 1 in 200 is about the least fall which should be aimed at and a sharper gradient, if possible, is advisable.

Ditch gradient and digging. When the ground elevations along the line of the main from its outlet and that of the future minors have been recorded, the gradient of the main ditch line is arrived at by deducting the ground elevation at the outlet, less the depth at the outlet, from the ground elevation at the top of the main less the proposed depth at this point. This figure divided by the length of the main gives the fall per foot. If unsatisfactory, an alteration in the depth at the outlet or upper end or both may be necessary. The gradient of mains on the College Farm has varied between 1 in 150 to 1 in 260 but, provided that the main used is of sufficient size, probably falls as low as 1 in 300 would be effective.

The ditch gradient of each minor is arrived at in the same way. No gradient should, if preventable, change from a low to higher one, as one passes up from the outlet of the main or from the outlet of minor into the main. The reverse is not objectionable ; but in the event of the necessity of changing from a low to a higher gradient on passing up a

drain a silt catchment box should be introduced as a precaution, though the amount of silting in such drains as have been opened up for examination after 2-3 seasons is remarkably small.

The digging out of the ditches of a system is generally done in the fair season. On account of the hardness of the soil and the necessity for pick, *phora* and *gamala*, 18″ has been the usual width dug. As the necessity for digging, grading, and laying the tiles as a continuous job is not essential, the usual process adopted has been to dig out the mains and minors to some standard depth given by the minimum depth along the line of drain—say 2′ 6″ all over the system—paying for this at the usual digging rate of 8 annas per 100 cubic feet. This work does not require skilled supervision and can be left to a contractor of normal intelligence. The only point is to see that the pegs which mark the points of known ditch-depth are replaced at the edge of the ditch. The soil to a depth of 1′ is thrown out on the right and the rest to the left of the ditch.

This being completed, the balance of the digging, the grading, and the tile-laying are proceeded with under a trained overseer's supervision. Usually, the extra depth of soil removed is of the width of about 9″—10″, giving a cross section of ditch as in Fig. 5. The depth of this portion

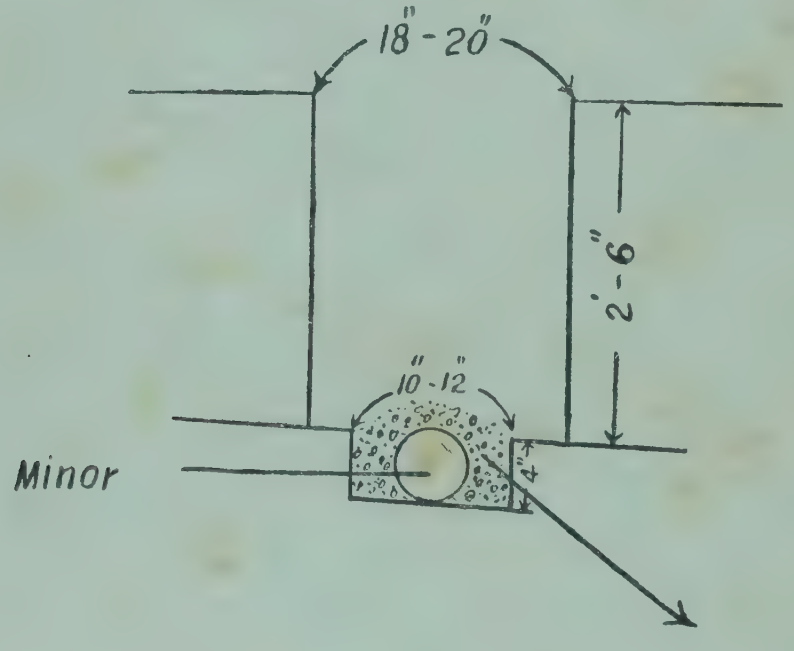


Fig. 5.

is decided by the ditch-depth marked on the pegs placed up the line of the ditch. The gradient of the ditch between these fixed points is arrived at by the use of plumb line and triangle on a ten foot plank laid on edge (as in Fig. 6), or better, by the device shown in Fig. 7. The digging

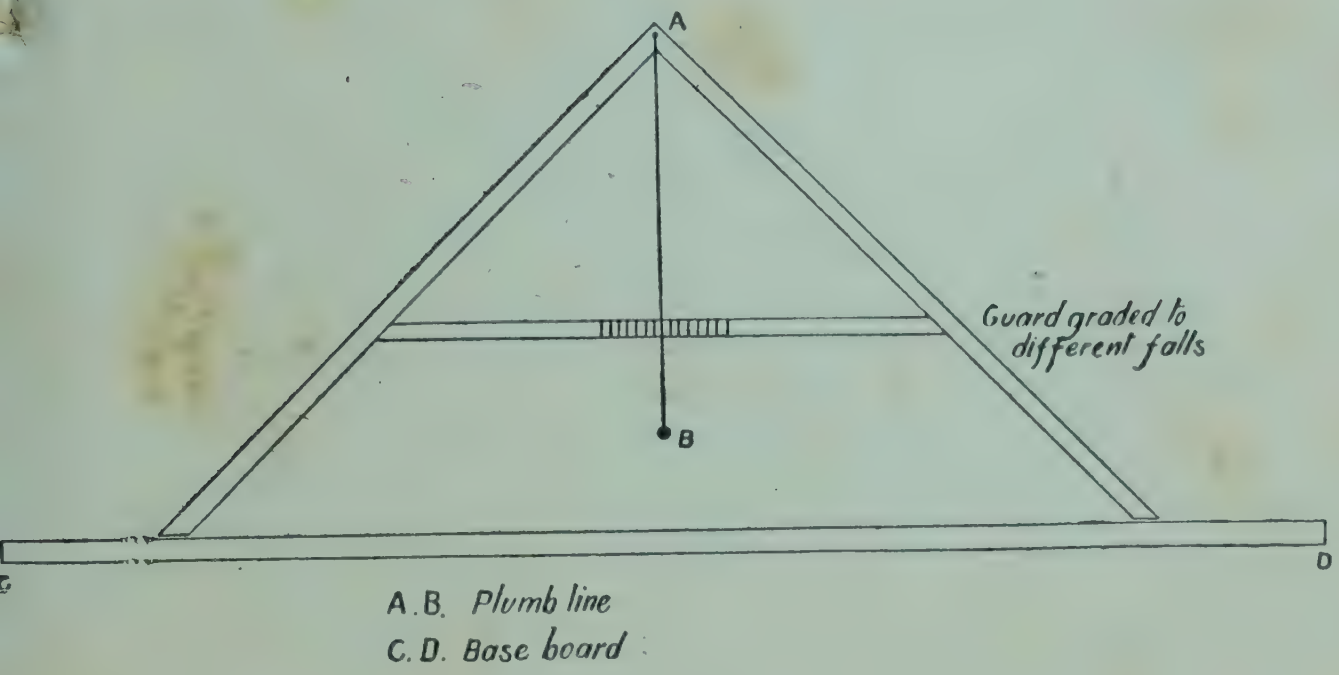


FIG. 6.

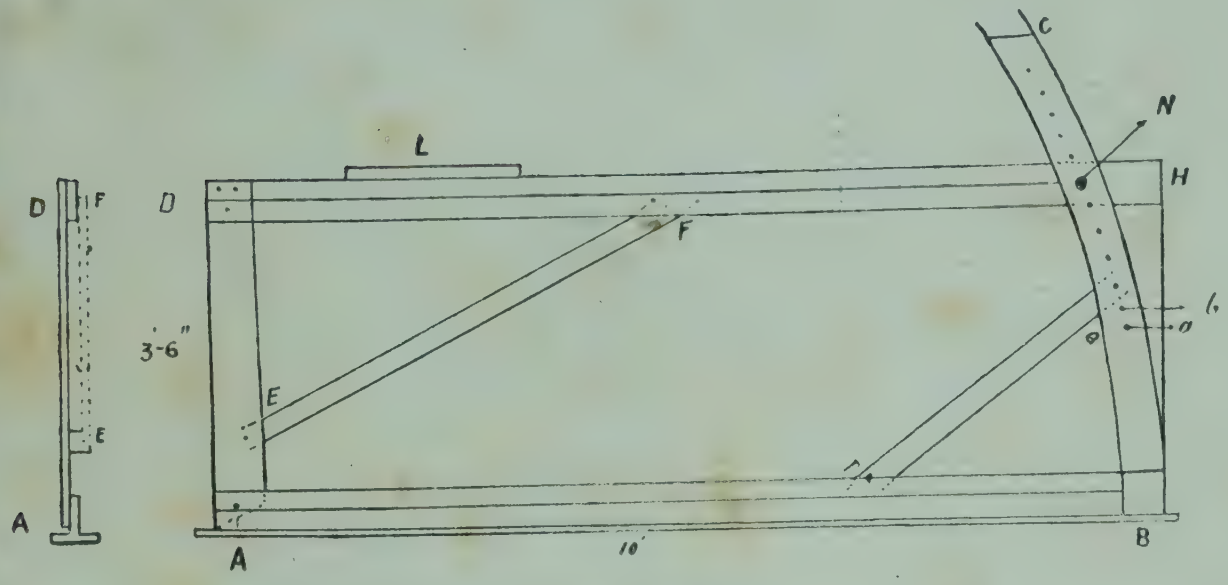


FIG. 7.

D H is 3″ × ¾″ deal plank 10′ long fixed at right angle to A D, a similar plank 3′ 6″ long and held rigid by the strut E F.

A B is a similar plank to D H, but with a base plank of same length (3″ × ½″) below it. It is fixed to C B and held in position by P Q, but is capable of turning at A.

B C is a plank fixed at B and held in position by the peg N according to angle desired. It carries a number of holes a, b, etc., which mark various falls.

L is a spirit level.

If a fall of 1 in 100 is desired, C B D is moved about the centre A, till the hole on C B, corresponding to 1 in 100 is over the fixed hole in D H, when N is inserted.

The instrument is then placed in the ditch bottom. The soil is scraped till the spirit level reads that it is horizontal when the correct gradient is arrived at.

and grading and pipe-laying proceeds from the outlet of the system up the main. The minors in turn are graded and laid from their outlets, the pipes being laid with their narrow end towards the outlet and kept in line. The writer has usually covered the tiles with a layer of coarse sand or fine gravel, after laying them and before the return of the earth to the ditch. This has been done to protect the pipe from clogging with fine soil. Whether this precaution is absolutely necessary is uncertain, but, if these coarse materials are easily procurable, it is probable that the slight extra cost of doing so is worth incurring, as giving the system a better chance of extended efficiency.

Junction of main and minors. The minor should invariably enter the main in the direction of the fall of the minor. The minors, to secure this, may be set at a slight angle to the main or if laid at right angles should be made to curve slightly on approaching the main. On the system on the College Farm, the minor pipe has been made to deliver on to the main pipe as shown in the section below. Fig. 8.

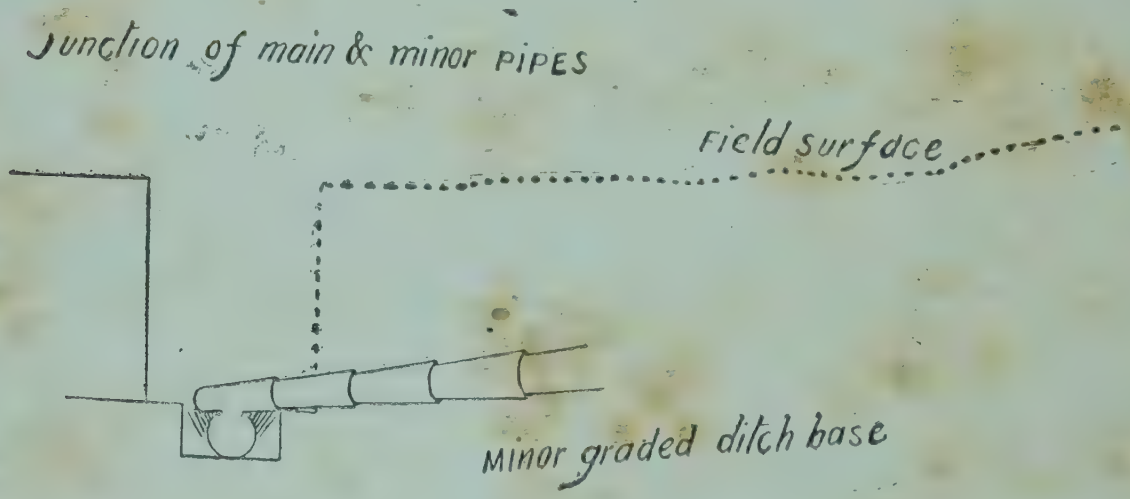
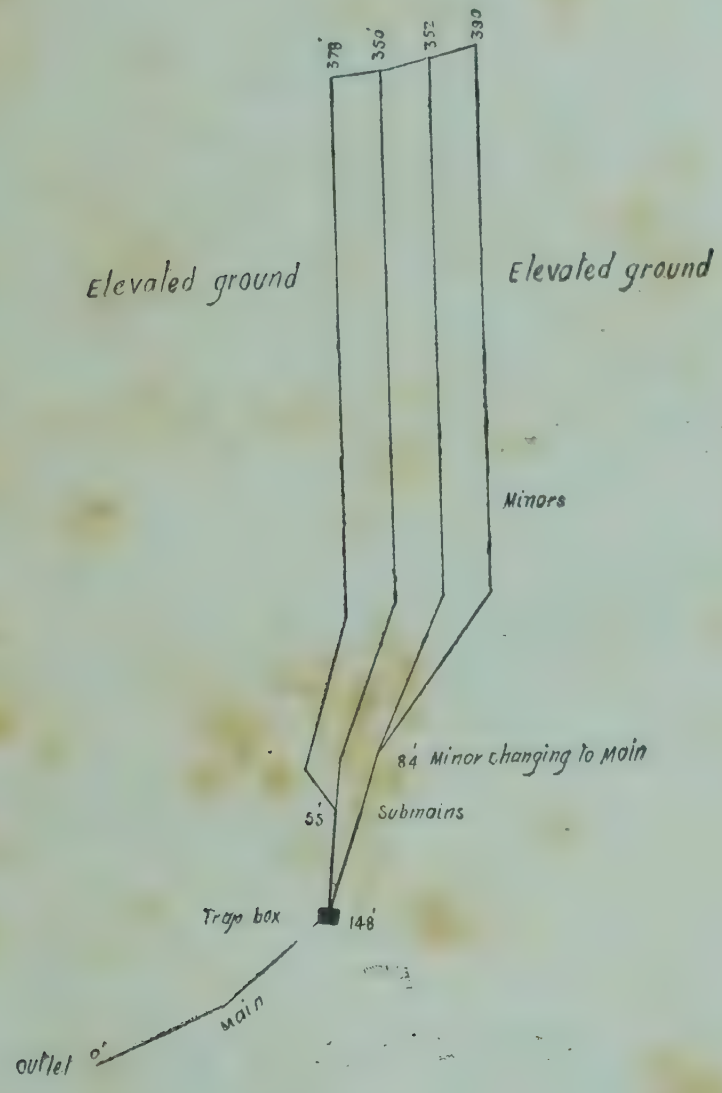


FIG. 8.

The outlet. This is a common point of possible weakness. It is advisable to protect the end with stones to prevent earth falling and blocking the mouth, and the end of the pipe must be covered with some wire net to prevent its use by vermin. In selecting the point of outlet into a ditch or *nullah* care should be taken to see that the water on leaving the pipe has a free fall and that the outlet is sufficiently high above the usual position of the water in the *nullah* in the monsoon to run no chance of being temporarily blocked by water except possibly in cases of abnormal flood.

The plans of these systems are attached—the first of the drainage of a field and the others of long hollows lying between two fairly naturally drained areas but themselves incapable, till drainage, of producing satisfactory *kharif* crops. An example is also given showing how the depth of a drain is arrived at after survey of the drain line. (Figs. 9, 10 and 11.)



Drainage system on field 41
Draining hollow.
Distance between minors 25 ft.
Fall of minors submain 1—100
Fall of main . . 1—200.
Average depth minors 2'-9"

FIG. 9.

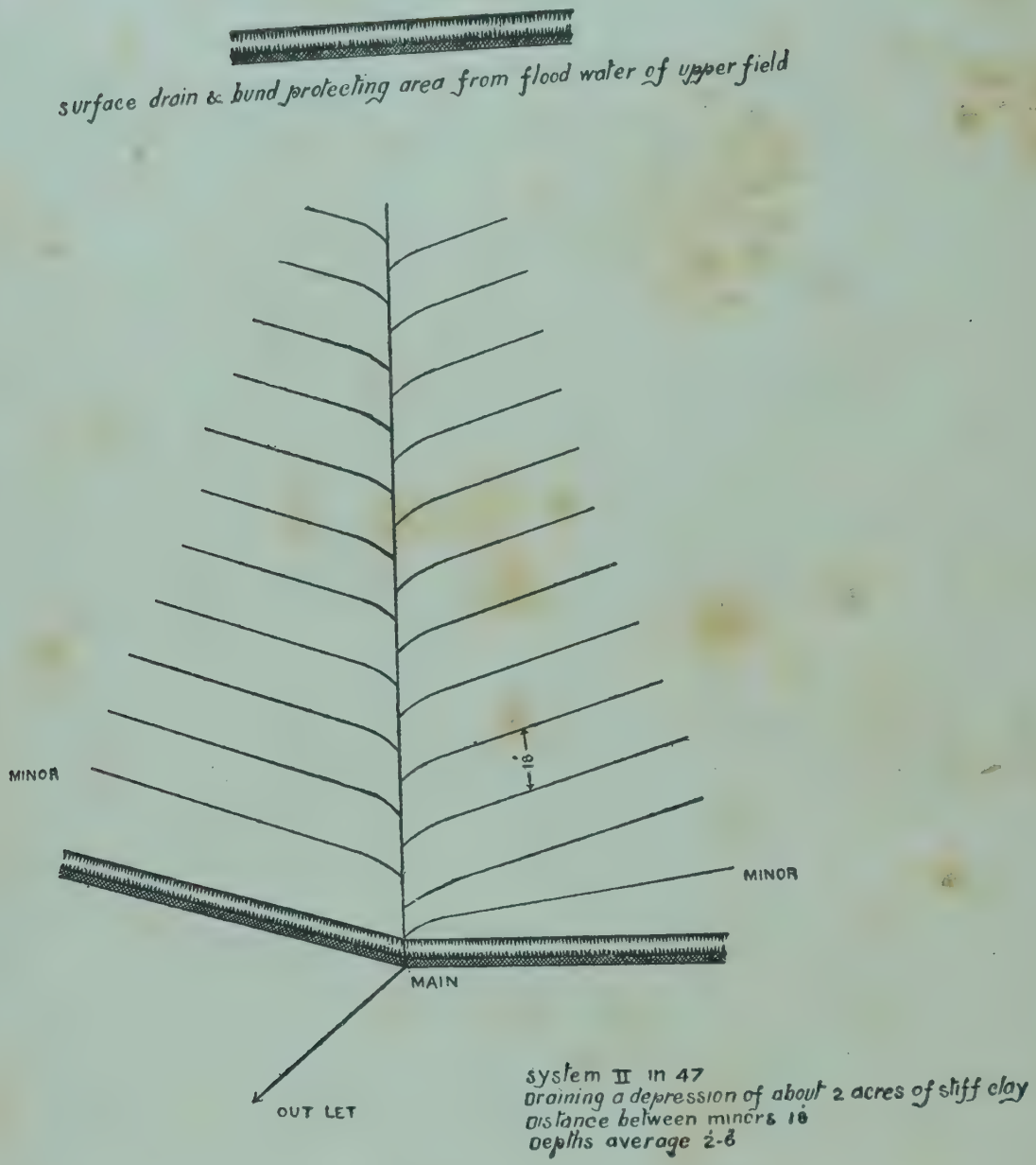


FIG. 10.

General effects. The effects of under-drainage have shown themselves in a steady growth of the plant throughout the monsoon, a dark green foliage and marked difference in maturity. The first picking of an under-drained cotton area is from 16 to 18 days in front of the first on the rest of the field, while *juar* and fodder become ready for harvest 2-3 weeks sooner. The staple of cotton is improved. The action of the drain has tended to reduce erosion, and the areas so treated, in spite of their unfavourable position, have been usually fit for cultivation from 24—36 hours after the heaviest rain and considerably before the higher

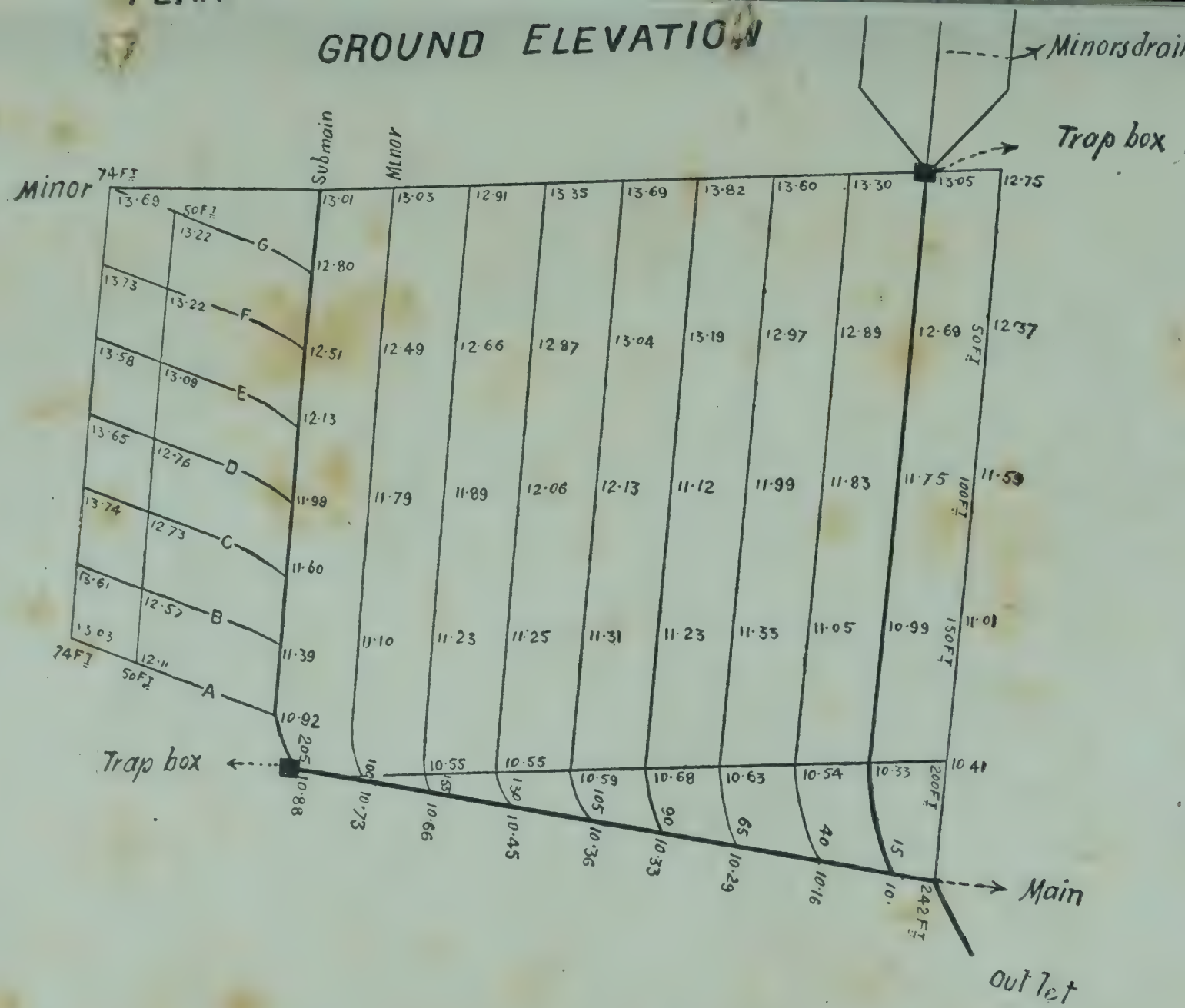

GROUND ELEVATION
Minors draining on upper field
Trap box
Minor
74 Ft
Sub main
Minor
50 Ft
G
F
E
D
C
B
A
Trap box
Main
Outlet
242 Ft
200 Ft
150 Ft
100 Ft
50 Ft

FIG. 11.

but undrained areas. This has allowed of greater cleanness and a very much improved mulch at the end of the rains. Casual observations of the roots show a tendency to deeper growth. As a result of this and of a better mulch, the plants appear to thrive better than those on undrained soil even after the monsoon has ceased and dependence has to be placed on subsoil water.

There has been but little trial of *rabi* crops on such areas. In a case of oats, grown under sewage in the cold weather as a fodder on the drained area, the crop does better than the same crop on undrained land when irrigated once a week, but slightly worse when only irrigated with sewage once a fortnight. This appears to indicate that crops of this season may be affected by the lower water table of drained land and their inability to get their roots down fast enough. Garden crops like cane, tomato, etc., are certainly benefited by drainage and are able to take fuller advantage of the somewhat frequent application of water necessary in sewage farming.

An approximate table of distance, depths and cost per acre has been worked out below.

Relation of ground elevation to drain depths.

Station	Distances	Ground elevation	Drain elevation	Depths
0	0	10·00	6·70	3·30 outlet.
1	15	10·00	6·79	3·21
2	40	10·16	6·92	3·14
3	65	10·29	7·05	3·24
4	90	10·33	7·18	3·15
5	115	10·36	7·31	3·05
6	140	10·45	7·44	3·01
7	165	10·66	7·57	3·09
8	190	10·73	7·70	3·03
9	215	10·88	7·83	3·05

(10·88—3)—(10—3·3)—1·18

Gradient of drain $= \frac{1{\cdot}18}{215} = 0{\cdot}054$ per ft.

bout 1 in 185.

Table showing approximate statement of materials and cost per acre.

Soil	Distances	Depths	Approximate number of minor pipes per acre	Approximate number of main pipes	Cost of pipes	Cost of excavation and grading	Cost of laying and filling	Total cost	If sand is used	Total cost including sand
	Feet	Ft. in.			Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
Free clay loam with some *kankar* .	26	3 0	2,520	350	59 6 0	36 12 0	15 12 0	111 8 0	12 0 0	123 8 0
Free clay loam .	24	2 10	2,830	350	65 8 0	41 0 0	17 8 0	123 0 0	13 8 0	136 8 0
Stiff clay loam .	21	2 8	3,150	350	71 8 0	45 0 0	20 8 0	136 0 0	15 0 0	151 0 0
Clay . . .	18	2 6	3,780	350	83 8 0	50 0 0	21 0 0	154 8 0	17 0 0	171 8 0

Prices based on—

Minor pipes	Rs. 19-0 per 1,000.
Main pipes	„ 30-0 „ „
Primary digging	„ 5-0 „ 1,000 c. ft.
Digging and grading	„ 6-8 „ „
Cost of laying and filling	„ 2-8 „ „
Cost of laying sand	„ 2-8 „ 100 c. ft.

A New Nematode causing Parasitic Gastritis in Calves.

(*Received for publication on 31st August, 1918.*)

THE parasite that is the subject of this note was found in immense numbers in the fourth stomach of several calves which had died shewing all the symptoms usually associated with parasitic gastritis, and there can be no doubt that it was responsible for the deaths.

The cases from which the specimens were obtained occurred in a small dairy herd in December, 1917, but pressure of other work prevented a detailed examination of the parasite at the moment. The worms were therefore preserved in normal salt solution to which one per cent. of formalin had been added. The description, measurements, and photographs are taken from these.

In measuring the length of the parasite, specimens were placed upon an accurately graduated slide in a few drops of the preserving liquid and the length read off directly. The thickness of the body was measured under a microscope. No coverglass was used; the worms were therefore not subjected to any pressure.

The measurements of other details of structure and the photographs cannot be accepted as accurate indications of size, as the parasites from which they were taken were under coverglasses and therefore subjected to some amount of pressure. In some cases considerable pressure had to be exerted in order to render certain details distinctly visible.

Male Worm. The male parasite ranges from 16 to 22 millimetres in length, with an average of about 20 millimetres.

The body attains its maximum thickness of about 0·4 millimetre, some 2 millimetres from the anterior end. For about 6 millimetres the thickness remains constant, posterior to which it decreases slightly, and at the hinder end of the body the thickness is about 0·3 millimetre.

At a distance of about 0·5 millimetre from the anterior end the body shews a small papilla on either side (Plate I, fig. 1). These are short, pointed, and directed very slightly backwards, and arise from saucer-like depressions in the cuticle.

The cuticle shews fine transverse striations throughout. These are most distinct along the thickest part of the body where they are about 2 microns apart. There are some eighteen longitudinal striations on each surface of the body.

In a fully grown male worm the cuticle is practically constant in thickness throughout except in the obtuse angle formed by the posterior end of the body and the wing of the bursa, where it shews distinct thickening (Plate IV, fig. 8*). In worms which do not appear to have attained their maximum size the cuticle is also somewhat thickened for a short distance at the anterior end of the body.

The œsophagus is club-shaped and measures 1·6 millimetres in length.

The intestine is straight.

The spicules present some special features. They are remarkably long and slender, measuring in a worm of average size (20 millimetres) nearly 6 millimetres (Plate I, figs. 2 and 3).

For the greater part of their length they run in close company. Anteriorly they diverge slightly and are somewhat expanded to form funnel-like structures (Plate II, fig. 4). Attached to these are a pair of oval bodies which appear to have very thin walls, and which measure 0·2 millimetre in their longer (antero-posterior) diameter. These structures are composed of two parts, the more granular of the two fitting over the other like a cap. Extending forwards from each of these are two thin-walled tubes (Plate II, fig. 4). Slight pressure on the coverglass is sufficient to render the oval bodies invisible, apparently owing to rupture. Posteriorly the spicules also separate from each other for a short distance, but come together again at or near their extremities (Plate I, fig. 2, and Plate III, fig. 7).

At the posterior end of the body there is a blunt conical process measuring about 80 microns in length and rather less than that in diameter at its base—the genital cone.†

On each side of this cone there is a somewhat triangular wing-like structure, the base of which is opposite the apex of the cone (Plate II, fig. 5).

The bursa comprises two large lateral lobes and a small dorsal lobe which is symmetrically placed.

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* The figures on the various plates have been numbered consecutively.

† This and other names used to designate anatomical details are those used by Veglia in his "Report on the Anatomy and Life History of *Hæmonchus contortus*." *Third and Fourth Reports (combined) of the Director of Veterinary Research, Union of South Africa*, Nov., 1915.

Owing to the spoon-like shape of the lateral lobes of the bursa, it appears to be impossible to flatten them out, while still attached to the body, for examination of the form and distribution of the supporting rays. It is, however, easy under a dissecting microscope to detach the large lobes and mount these separately.

In each lobe there are six rays and they are disposed as follows (Plate II, fig. 6):—

There is a single ventral ray (A) which measures about 200 microns in length, is curved ventrally and tapers gradually to a rather blunt point.

There are two long stout middle rays (B and C) which run together throughout their length. Of these the more dorsal is slightly the longer. These rays measure about 600 microns in length and 70 microns in width at their thickest part. The free ends are slightly expanded. Dorsally there are three slender and progressively shorter rays (D, E, and F). These all shew a general curve in the dorsal direction and range from 400 to 250 microns in length.

The most ventral of these (D) is always so curved as to bring its point close to that of the next ray (E).

The middle ray (E), although shewing a general curve in the dorsal direction, is usually slightly recurved at its tip. The most dorsal ray (F) is slender and more pointed than the other two.

The posterior lobe is, in the full grown worm, far smaller than the lateral lobes, but examination of male parasites that have not attained their maximum size shews that in these the posterior lobe is proportionately much larger (Plate II, fig. 5). The ray supporting this lobe (Plate III, fig. 7) has a stout, somewhat tapering main trunk from which arise two branches. Each of these terminates in two rounded tubercles, of which the outer is the larger. The inner tubercle frequently shews a small bud-like projection, and on the inner sides of the main branches there are frequently found a pair of similar projections.

On either side of the body just anterior to the attachment of the main lobes of the bursa, the subcuticular tissue shews a conical outgrowth about 15 microns in length (Plate II, fig. 5).

Radiating from points opposite the base of the genital cone on either side are bands of muscle fibres passing round the bases of the lobes of the bursa (Plate IV, fig. 8).

Female Worm. The female parasite ranges from 20 to 26 millimetres in length, with an average of 23·5 millimetres. The body is slightly thicker than that of the male and tapers to both extremities. Posteriorly the body terminates in a sub-acute tail which is curved slightly in the ventral direction.

The œsophagus and intestine are like those in the male. The anus opens at a point about 160 microns in front of the tip of the tail (Plate IV, fig. 9).

The vulva which takes the form of a transversely placed orifice with somewhat prominent lips is situated about 560 microns from the tip of the tail. No lingual appendage such as is found in *Hæmonchus* has been seen (Plate IV, fig. 9).

Extending forwards from the vulva is the vagina which runs a practically straight course and measures about 2·8 millimetres (Plate V, fig. 10).

At its anterior end it makes a T-shaped junction (Plate V, figs. 11 and 12) with a short tubular structure which measures 250 microns in length (the unpaired part). This tube is placed more or less in the longitudinal axis of the worm, the vagina having therefore to make a right-angled bend to enable it to effect a junction with its middle point.

At each end of the unpaired part is an oval enlargement measuring about 140 microns in the long diameter. This appears to correspond with the " pars ejectrix " of the ovijector described by Veglia.

From each of these a tube about 480 microns long and with thick walls takes origin. That arising from the anterior one passes directly forwards and that from the posterior one making an immediate bend so as to pass forwards also.

A globular thickening (the " pars haustrix " of the ovijector, Veglia) marks the point where these thick-walled tubes are succeeded by thin-walled tubes of much larger calibre—the uteri. These measure about 3 millimetres in length.

Extending forwards from the uteri are the ovaries which in fully mature females are packed with eggs in various stages of development. No recognizable embryos were found in any of the eggs in the uteri.

The ovaries run in company with each other and make four or five spiral turns round the intestine. They become gradually reduced in lumen and terminate blindly. The ovaries measure from 7 to 9 millimetres in length.

Identity of the Parasite.

A search through the literature has failed to reveal any reference to a nematode parasite having the characters of that described above.

According to Neveu-Lemaire* the nematode parasites of the fourth stomach and duodenum are comprised in six genera of the sub-family *Trichostrongylinæ*, namely :—

(1) *Hæmonchus*, Stiles 1903.

* Neveu-Lemaire. " Parasitologie des Animaux domestiques," 1912.

(2) *Graphidium*, Railliet & Henry 1909.
(3) *Nematodirus*, Ransom 1907.
(4) *Trichostrongylus*, Loos 1905.
(5) *Ostertagia*, Ransom 1907.
(6) *Cooperia*, Ransom 1907.

Species belonging to all these genera with the exception of *Graphidium* are found in the fourth stomach and duodenum of ruminants.

The following table shews the distinguishing features of these genera, and is based upon descriptions given by Neveu-Lemaire,* Macqueen,† and Pillers.‡ The corresponding features of the worm described in this note are given for comparison.

	Caudal bursa	Spicules	Vulva
Hæmonchus . . .	Trilobed; dorsal lobe asymmetrical	Short and stout with an accessory piece	$\frac{1}{5}$ to $\frac{1}{6}$ from posterior end of the body and covered by a lingual appendage
Nematodirus . .	Bilobed . .	Long and slender .	About $\frac{1}{4}$ from posterior end of the body
Trichostrongylus .	Bilobed . .	Short and twisted .	Near the posterior end of the body
Ostertagia . .	Median lobe insignificant or absent	Short and stout, and cleft at tips	$\frac{1}{10}$ from posterior end of the body
Cooperia . . .	Median lobe insignificant	Short and stout with accessory piece	$\frac{1}{4}$ from posterior end of body
Worm described in this paper	Trilobed with posterior lobe symmetrically placed	Very long and slender	Close to the posterior end of the body (about $\frac{1}{40}$)

From this it would appear that the parasite is not identical with any species previously recorded, and, further, that it does not fall into any of the established genera.

* Neveu-Lemaire, loc. cit.
† Macqueen. "Neumann's Parasites," 2nd Edition, 1905.
‡ Wallis Hoare. "A System of Veterinary Medicine," Vol. II, 1915.

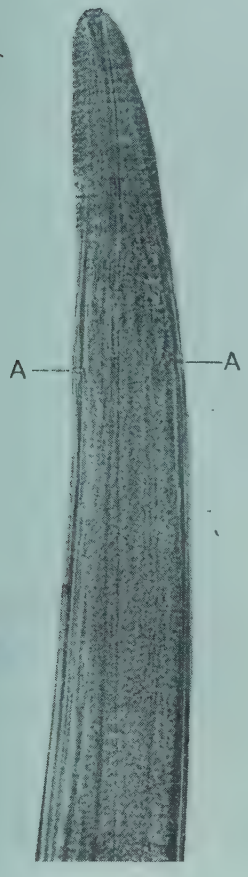

Fig. 1. Head of male × 75.
A, cervical papillæ.

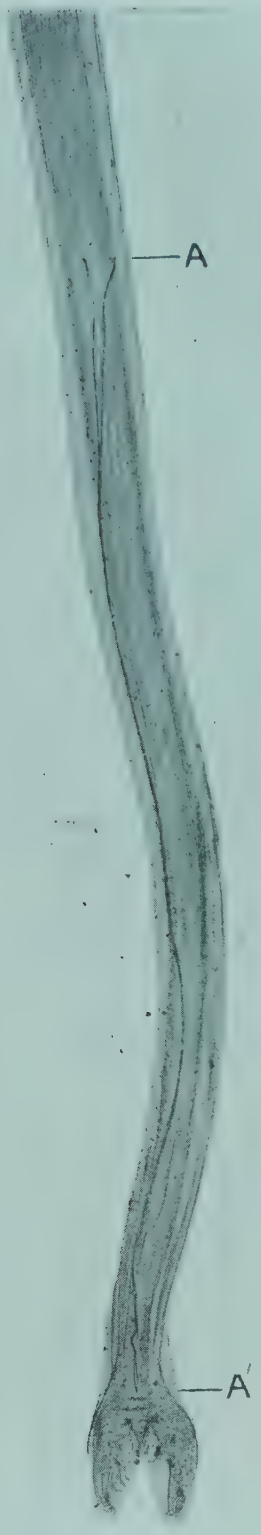

Fig. 2. Posterior part (about one-third) of male × 20.

A to A^1, spicules. The divergence at the anterior extremity is shewn at A, and the posterior divergence and reunion at A^1.

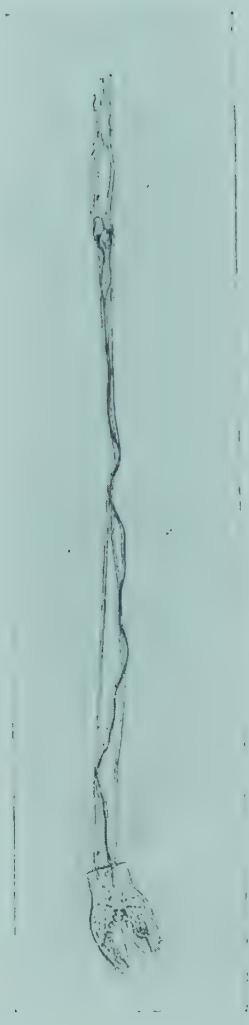

Fig. 3. Genital organs of male × 12·5.

It was found possible to extract these by tearing through the cuticle on either side of the worm close to the bursa with the point of an ordinary needle and by exerting gentle traction with the needle pressed flat on the bursa.

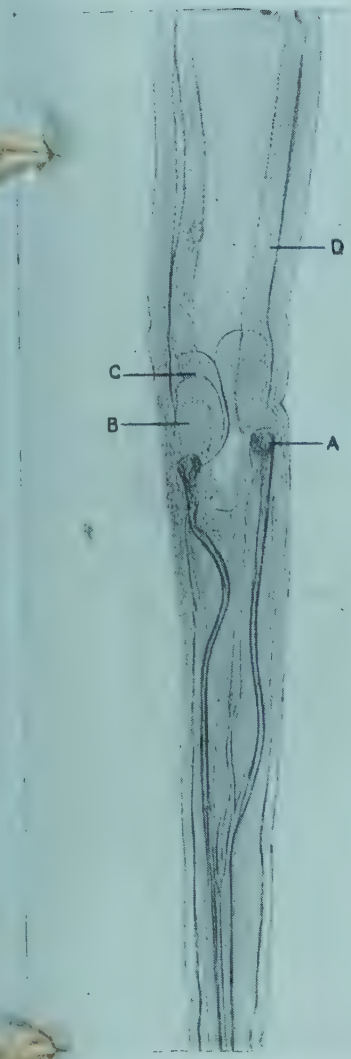

Fig. 4. Part of the male generative organs × 75.

A, funnel-like expansion of the anterior end of the spicule.
B, "oval body" attached to the spicule.
C, granular cap-like part of the "oval body."
D, thin-walled tubes running forwards from the "oval bodies."

Fig. 5. Caudal bursa of male × 150.

A, genital cone.
B, B, triangular wing-like structures on each side.
C, C, positions occupied by the conical outgrowths.
D, middle lobe. The parasite from which this photograph was taken had not attained its full size; the middle lobe of the bursa is therefore proportionately large.

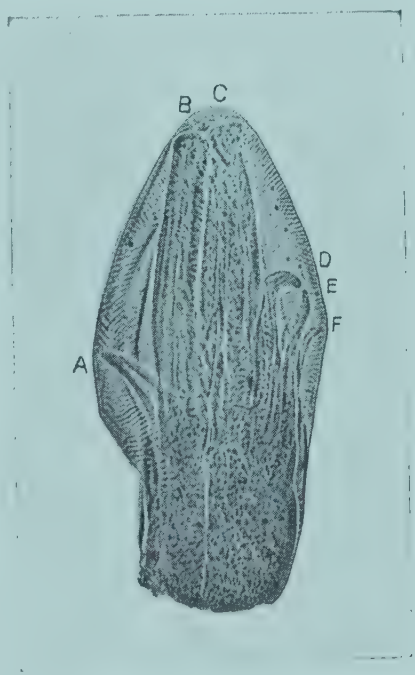

Fig. 6. Detached lobe of caudal pouch × 75.
A, ventral ray. B, C, middle rays.
D, E, F, dorsal rays.

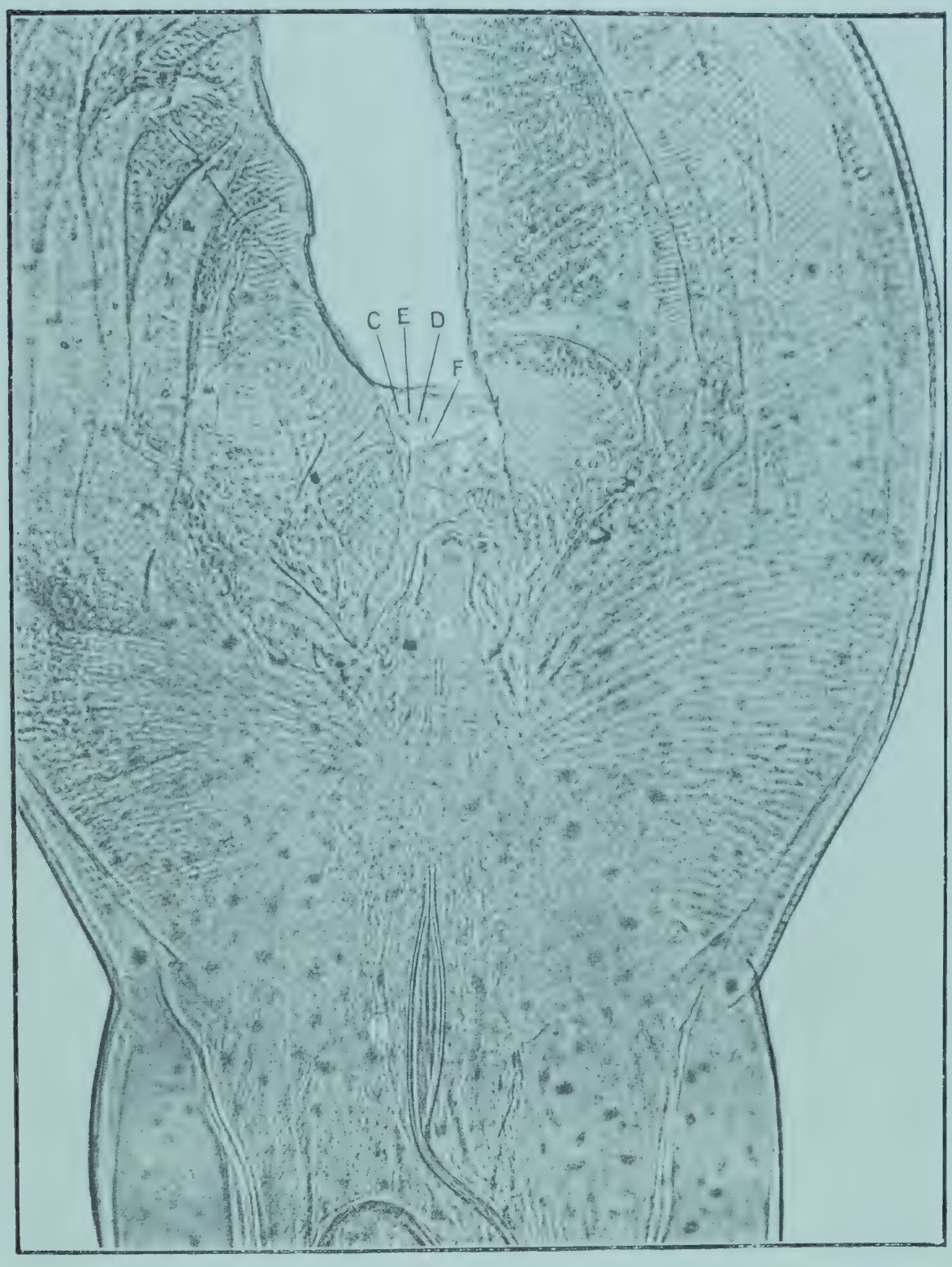

Fig. 7. Caudal extremity of male shewing the ray supporting the posterior lobe × 300.

A, main trunk.
B, B. primary branches.
C, outer tubercle of primary branch.
D, inner „ „ „
E, bud-like projection on inner tubercle.
F, club-like projection on inner side of primary branch.
G, genital cone.
H, terminal divergence and reunion of spicules.

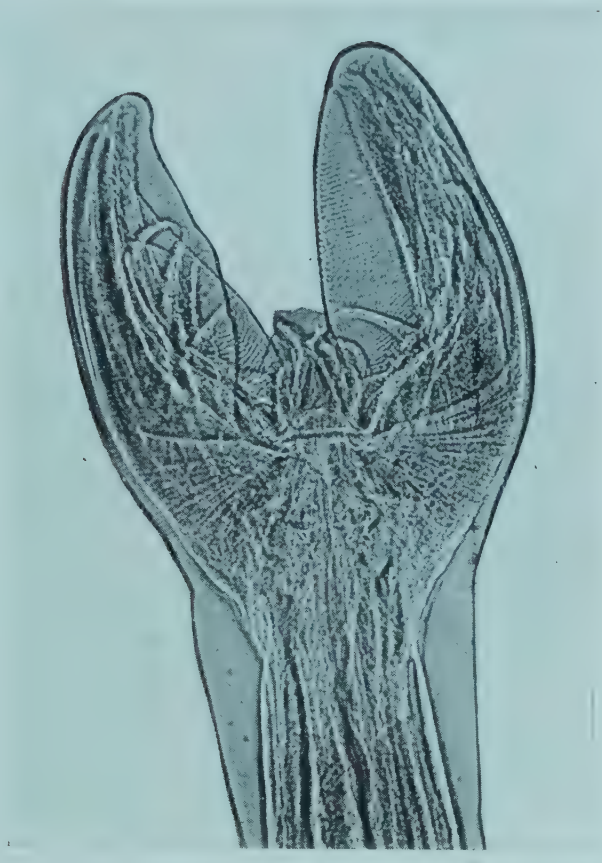

Fig. 8. Bursa of male worm × 75.
Showing muscle fibres radiating from opposite the base of the genital cone.

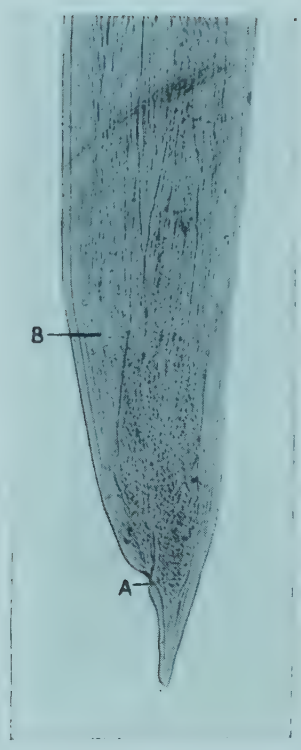

Fig. 9. Tail of female × 75.
A, anus.
B, vulva.

Fig. 10. Posterior part of female worm × 12·5.

A, anus.
B, vulva.
B—B¹, length of vagina.

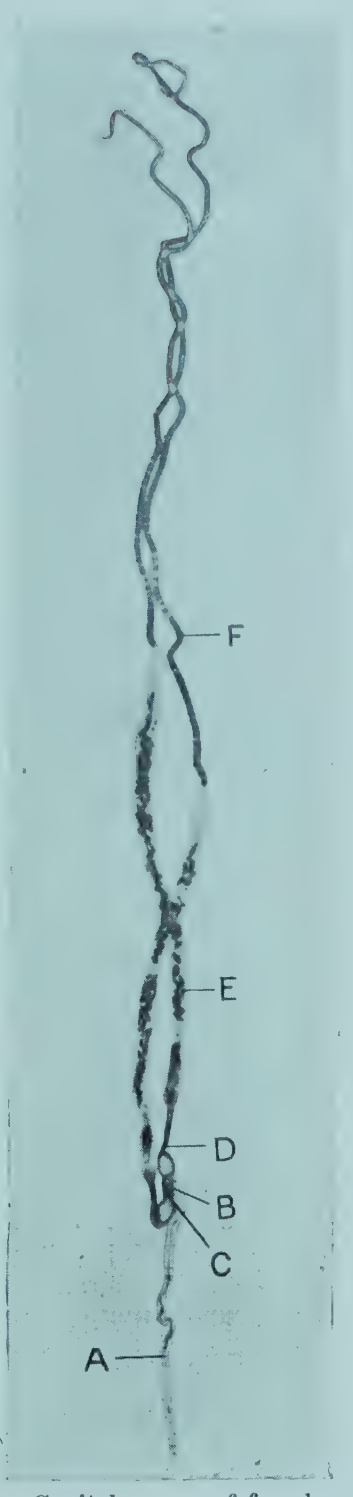

Fig. 11. Genital organs of female × 12·5.

A, vagina.
B, junction of vagina with "unpaired part."
C, "unpaired part."
D, ovijector.
E, uterus.
F, ovary.

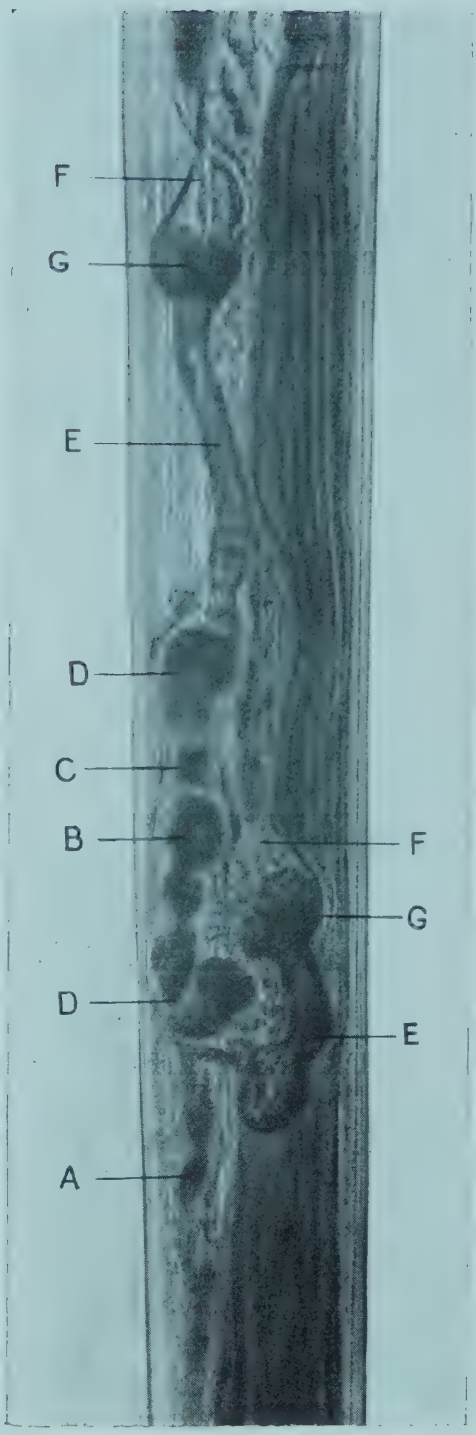

Fig. 12. Part of the genital organs of female × 75.

A, vagina.
B, junction of vagina with "unpaired part."
C, "unpaired part."
D, D, "oval enlargements."
E, E, "thick ovalled tubes."
F, F, uteri.
G, G, globular thickenings.

It was found possible to extract these in the following way :—

The anterior end of the worm was held under the slide clip of the dissecting microscope. The body was cut right across just in front of the vulva. By making "stroking" movements with the side of an ordinary needle pressed gently on the worm well forward in the body the intestine was divided without breaking the cuticle. By sliding the needle along the body the intestine and generative organs were extruded at the cut end of the worm and then separated from each other.

A Contribution to our Knowledge of South Indian Coccidæ.

[*Received for publication on 13th May, 1918.*]

Introduction.

THIS family of insects—including what are popularly known as scale insects and mealy-bugs—is one of those groups of lower animals which have not received sufficient attention till now in South India. This is due to various causes. In the first place, most of the members of this family are in their general structure and habits quite unlike the ordinary run of insects; they are generally minute and inconspicuous and often mistaken for lifeless things and overlooked. Secondly, the comparatively rare occurrence of these insects on ordinary field crops has also retarded the attention which these creatures might otherwise have received in company with insects affecting ordinary crops. While the great majority of scale insects and mealy-bugs infest trees of different kinds, garden shrubs, ornamental plants, etc., there are very few of them which infest field crops like paddy, sorghum, cotton, etc. In parts of America, South Africa and Australia where fruit trees are extensively grown, some of these insects have become serious pests, and in certain cases assumed the status of a regular menace to fruit culture. A well-known scientific worker in California remarks, "If we except the water problem, and possibly that of fertilizers and cultivation, no question concerns the growers of *Citrus* fruits in California more than that of scale insects." The well-known San Jose Scale, the Fluted Scale, the Cottony Cushion Scale and the Red Orange Scale are only a few of the notorious pests of this family of insects causing considerable trouble in the orchards of America, Australia and various other countries in the tropics. In South India, on the other hand, with the exception of two members of this group, the Green and the Brown Bug of Coffee with which some of the European planters in the hill districts are familiar, very little is known of the individuals of this family, although numerous species occur in the country.

In view of the fact that some attention is nowadays being paid all over the country to develop fruit culture, there is a chance of these insects,

many of which are partial to fruit trees, coming into some prominence. Perhaps, it is not well known that some of these scale insects are introduced from country to country in nursery stock, fruits, hot house plants, etc., and when thus introduced some often exhibit a tendency to become very serious pests in their new homes. There is no other group of insects the ravages of which have been so much increased by human agency than the family of Coccidæ. And in order to prevent this spread of noxious insects even legislation is resorted to in many countries. "Scale insects are, as a rule, small and inconspicuous singly, but they multiply so rapidly that very soon an entire plant becomes infested—trunk, limbs, leaves and fruit. The infested tree is rarely killed outright, but its growth may be almost completely checked and its fruit products rendered valueless." Watt and Mann in their account of the " Pests and Blights of Tea " remark, " It is of the greatest importance that these insignificant-looking insects should be clearly recognized and their injurious action fully understood, not merely because of the present injury they are effecting, but to a far great extent because of their possibilities of infinite mischief in the future."

The object of this paper is, therefore, to give an account of the species of Coccids so far known to occur in South India with special reference to those having some economic importance, and I believe it may be of some use not only to those who are doing systematic work on this group to add to the knowledge of the Coccid fauna of the country, but to many prospective planters, orchardists, horticulturists and nurserymen ; to the latter the paper might be of some help in recognizing these creatures when they happen to infest their plants and thus get timely warning to devise early measures to control them. As far as possible all minute structural details or technicalities are avoided both in the text and in the illustrations.

General features and life-history of Coccidae.

A few introductory remarks regarding the general features in the structure and life-history of Coccids will not perhaps be out of place here. The insects belonging to this group are all small in size, the giants of the family not measuring more than an inch at the most. Almost all of them have some sort of covering produced by the insect itself ; this covering may be of waxy, horny, glassy or resinous secretion, or some sort of powdery white material. Those having a clothing of loose white mealy substance are generally called mealy-bugs, all others being known as scale insects. The adult female is wingless and leads a stationary life fixed to the plant surface except in the case of mealy-bugs which are able to move about slowly all their life.

All are vegetable feeders and possess a well-developed thread-like sucking tube by means of which the plant sap is sucked up. The following will give a brief idea of the life-history of a typical scale insect ; of course, there are exceptions to this.

The female insect produces numerous minute eggs and out of these tiny larvæ hatch out ; these larvæ possess 6 legs, a pair of feelers, a well-developed feeding tube and minute eyes. The larvæ crawl about the tender branches of the host plant and after a time, which may be a day or two, anchor themselves at some spot on the tree by means of the beak and there grow by feeding on the plant sap. The periodical moulting takes place and the larva then loses its original form, becoming a small footless mass covered over by a scale-like secretion. The male and female larvæ are very rarely separable at this stage. After one or two more moults the male insect generally emerges out as a small delicate wingless or a two-winged creature, mates with the female and then dies. The females, on the other hand, become fixed to the plant for life ; they lose their feet, feelers, etc., becoming irregular in shape, and grow by feeding on the plant sap and secreting the scale-like cover called the puparium. They are fertilized by the male and after this the female insects grow rapidly and the outer scale increases in size. By the time the eggs inside the female become mature and approach the hatching time, the soft portions of the mother under the scale gradually shrink and she dies away allowing the eggs to hatch and thus giving rise to a fresh generation. The puparia of male insects are generally smaller in size, and it is the scales of the female Coccids that we often see prominently on badly infested plants. The puparia of the male and female insects of the same species many a time show differences in structure.

In addition to reproduction by actual sexual union, many of these insects possess the power of reproducing by parthenogenesis—a phenomenon where the female insect is able to produce young ones without the help of the male ; in many species the male is still unknown. Some species of Coccids instead of giving rise to eggs very often produce viviparous young ones. These properties account for the enormous and rapid multiplication of these insects. The period of their greatest activity is summer and it is during this time they breed rapidly. In the cold or rainy weather, though they are dormant, breeding continues, but at a very much reduced rate.

Distribution and means of dispersal.

There is hardly any tree or plant which is not subject to the attacks of one kind or other of scale insect ; some attack cultivated plants of

different kinds, while a good many others are found on various wild plants and trees. There are, however, certain species which confine themselves to certain kinds of plants, while others are general feeders and found on various kinds of different plants. Change of conditions often brings about remarkable changes in the habits of these insects, and we cannot say when one apparently harmless species may become a pest and when a wild feeder might transfer its activities to cultivated plants. Though these insects are stationary for the greater part of their lives, there are various agencies which play their part in spreading scale insects from tree to tree and from one tract to another. It may often be surprising to note how these insects, many of which are not only wingless but footless, become so very widely distributed. This is explained by the fact that during the very early stages in the life of these insects when the minute larvæ are fairly active and move about in the different parts of the host plant they are easily carried on the limbs and bodies of various animals which visit this plant. Common examples of these are various kinds of beetles, caterpillars, spiders and different kinds of birds ; often eggs of scales are rubbed off by such animals and carried to new localities. The following observations of Hubbard on this point will be found very interesting :—" During the migratory stage the restless habit of the young bark lice impels them to crawl about actively, turning aside for no obstacles but mounting every object met with in their path. The instinct of self-protection being entirely wanting in these degraded creatures, they make no distinction between dead and living objects, and crawl without hesitation upon the bodies of other and larger insects. The latter impelled by the annoying presence of the intruders fly away bearing with them the scale larvæ, and thus assist in distributing them upon surrounding plants. But spiders more than any other animals must be considered efficient instruments in this mischievous work. Not only do they transport the lice—and it is an observed fact that the movements of the latter upon their hairy backs do not incommode the spiders—but they also harbour them under their webs in folded leaves, etc., where safe from the attacks of parasites and enemies they increase and multiply inordinately." Ants of various kinds play a very important part in the dissemination of different kinds of Coccidæ, especially the unarmoured species of the family. A strong wind or storm is also able to carry away these delicate young ones from tree to tree.

In addition to all these, there is the important factor of human agency sending plants and trees of various kinds from one place to another. The spread of many scale pests might be traced to this agency since at present there are easy facilities for transport of infested fruits, shrubs,

plants, etc., from one part of the world to another. It is a knowledge of this method of dissemination by commerce that has made many advanced countries to establish a quarantine system to prevent the introduction of new and undesirable pests into their country. India is at present fortunately free from some of the worst scale pests which do considerable damage in the Western countries, and if sufficient precaution is not resorted to in time there is little doubt that some of these bad pests might gain entrance into the country. It is due to the importance of this aspect of the question that I have dwelt at some length on the distribution of Coccidæ.

Enemies of Coccidae.

Of the enemies of Coccids the most important are ladybird beetles and small hymenopterous wasps. The former are generally predaceous, while the minute wasps are internal parasites. In some of the Western countries where a knowledge of these enemies has considerably advanced, attempts have been made to import such natural enemies of scale insects from foreign countries as a method of control, and in some countries this method of checking certain scale pests has met with phenomenal success. Though something is known of the predaceous enemies of scales, comparatively little is known of the minute parasitic wasps that sometimes do a considerable amount of good work. The presence of these parasites can only be made out by the trained observer ; a parasitized colony of scales will show minute holes on the scales which is the result of the emergence of the wasp which was inside the insect. A knowledge of the presence of these insects will help the gardener in deciding as to whether the application of any insecticide is necessary or not ; the latter will not only be found unnecessary when the scales are found parasitized but the application will do harm by destroying the beneficial insects. Besides these insects there are certain species of lepidopterous larvæ (species of *Eublemma* in India) found doing some beneficial work as natural enemies in checking the multiplication of certain species of Coccids.

Classification of Coccidae.

The family is divided into a number of subfamilies as will be seen from the following pages. For all practical purposes, however, the family may be conveniently divided into two groups popularly known as " armoured " and " unarmoured " scales. The former are characterized by the possession of a protective scale which is hard and tough. Some of the forms included in this group are the worst enemies of

different kinds of cultivated plants, especially fruit trees, and very difficult to exterminate. The important genera are *Chionaspis*, *Aspidiotus*, *Diaspis*, *Mytilaspis* and *Parlatoria*. The unarmoured scales on the other hand include forms which are not so well protected, the body itself becoming more or less modified for protection ; it is either soft and naked or is covered by waxy, cottony or glassy secretion. This group includes the soft scales, mealy-bugs, mealy scales, cottony bugs, etc. It is sub-divided into several subfamilies, and the chief genera are *Pulvinaria*, *Lecanium*, *Pseudococcus* and *Icerya*.

Previous records of Coccids from South India.

The earliest record of a member of this family from South India appears to be that of the " Indian White Wax Insect "—*Ceroplastes ceriferus*, And.—by Dr. J. Anderson from Madras in the year 1790.[1] In his " Letters to Banks (1786-89) " Dr. Anderson has also recorded a few more forms of Coccids from the Madras Presidency, but his descriptions of them are so meagre as to be of no use to modern workers in recognizing the species referred to. For the next record we come down to 1886, in which year Atkinson published his paper on " The Homopteron family Coccidæ " in the *Journal of the Asiatic Society of Bengal*. In this paper the only definite species referred to as recorded from South India are *Ceroplastes ceriferus*, And., and *Monophlebus leachii*, West., the former from Madras and the latter from Malabar and Pondicherry. The later records of Coccids since then are to be found chiefly in the pages of *Indian Museum Notes*, a very valuable publication, now defunct, by various workers. In p. 59, Vol. II, No. 1, 1891, Maskell has described *Eriochiton cajani* from South India, and in page 168, No. 6 of the same volume are recorded *Lecanium viride* and *Dactylopius adonidum*. In Vol. III, No. 5, 1894, Professor Newstead has described some forms collected in Madras by Miss Tomlin in 1892-1893. These include the new forms *Pulvinaria obscura*, *Dactylopius ceriferus* (*virgatus*), *Dactylopius viridis*, *Aspidiotus orientalis*, *Icerya ægyptiacum* and *Lecanium hemisphæricum*. In 1895 Mr. E. E. Green described *Aspidiotus moorei*, from Madras, in the *Entomologist's Monthly Magazine* (Vol. VII). Again in Vol. IV of *Indian Museum Notes* (pp. 211-212) two South Indian forms are described, *viz.*, *Diaspis calypteroides*, Costa, var, *cacti*, Comst., and a variety of the cochineal insect. To Vol. V, No. 1, Mr. Green contributes his remarks on Indian Coccidæ and gives a resumé of the previous records of Indian Coccidæ and in this no new forms other than those noted

[1] Anderson, J. " Monographia cocciceriferi, " Madras, 1790.

above are recorded as South Indian. In part II of his paper which appeared in Vol. V, No. 3, of *Indian Museum Notes*, two new forms from South India are added, *Lecanium imbricans* and *Inglisia bivalvata*. Part III of Mr. Green's paper appeared as a Memoir of the Department of Agriculture in India in 1908, and in this the author adds a dozen more new forms to the already recorded forms from South India. In the *Records of the Indian Museum*, Vol. VII, Part I, Mr. Green describes two or three species of *Margarodes* from South India, and Lindinger in the pages of a German periodical [1] has recently (1911) described two species of *Mytilaspis* from South India.

So far as I know this concludes the previous records up to date. It is thus found from the above references that about forty species have been so far recorded from South India till now. As a result of my collection and some special attention paid to this group during the past two years, it has been possible to bring this number up to 129 so far as my collections have been worked out; and there is no doubt that more may be added when the remainder of my already collected material is gone through.[2] Nor is there any doubt that when all the tracts of the Presidency are thoroughly worked out, especially the hill tracts (most of the forms described in this paper are specimens from the plains), the number of species would increase enormously. I am very much indebted to Professor R. Newstead, F.R.S., and to Mr. E. E. Green, F. E. S., two of the foremost authorities on Coccidæ, for their kindness in identifying the material submitted to them by me; and I am especially grateful to Mr. Green for the readiness with which he helped me from time to time and for his valuable suggestions with regard to the study of this group of insects.

Of the 129 species recorded in this paper, only 40 have been noted before from South India; of the rest, 18 are species new to science and all the others noted for the first time in this tract. Most of the new ones are being described in detail by Mr. Green, and will, I understand, be published soon. Among the new records several are quite new to India and some of them are pretty bad pests outside India. There is little doubt that at least a few of them are foreign forms and must have been introduced into India through nursery stock, fruits, seeds, bulbs, etc. In a paper[3] read before the Indian Science Congress, Lahore, in January, 1918, on "Some South Indian Coccidæ of Economic Importance," I have included 32 species which have so far been noted to be of some economic importance.

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[1] *Zeitschrift f. Wiss. Insektenbiol.*, VII, 1911.

[2] Unfortunately it is not possible in these days to get specimens identified from Europe, and so I have not been able to get all the material at my disposal determined.

[3] Since published in the *Journal of the Bombay N. H. Society*, Vol. XXVI, page 621—628, 1919.

The great majority of the species noted below were collected in the Plains of South India, chiefly in and around the Coimbatore Agricultural College, and very little of the hills and the coast tracts has been explored. Though the great bulk of the material was collected by me I have had some help in the shape of material collected by the staff of the Government Entomologist's office and to them my thanks are due. I have added the names of the collectors in all those cases where I have not collected specimens of the species myself.

With regard to the arrangement of the forms, I have followed that of Green in his " Coccidæ of Ceylon."

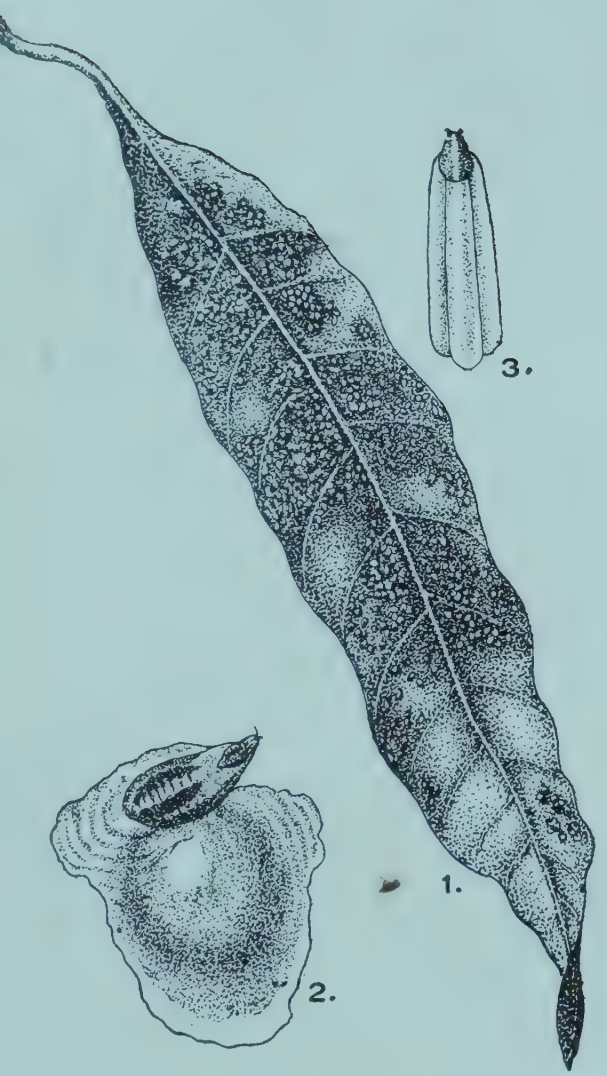


Fig. 1. *Chionaspis vitis*, Green.
(1) Scales on mango leaf; (2) Female puparium, magnified; (3) Male puparium, magnified.

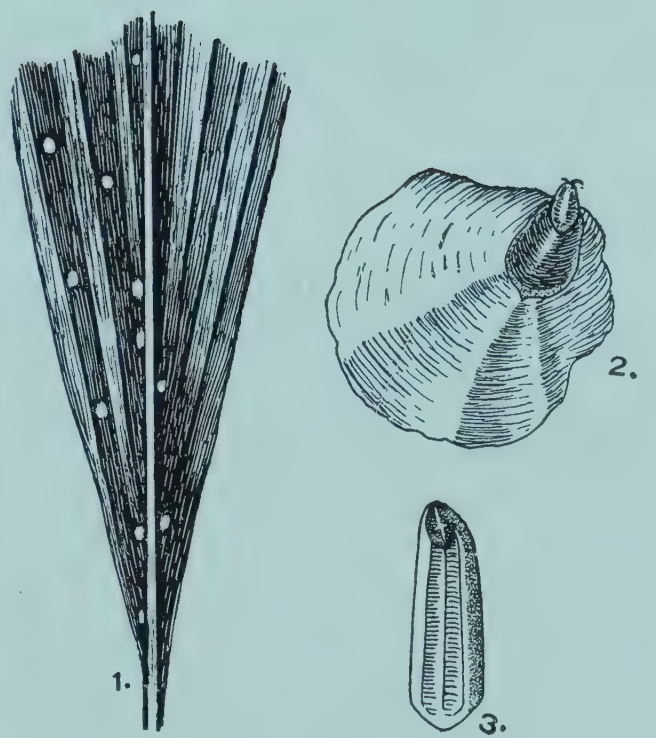


Fig. 2. *Chionaspis dilatata*, Green.
(1) Scales on palm; (2) Female puparium, magnified; (3) Male puparium, magnified.

Fig. 3. *Chionaspis varicosa*, Green.
(1) Scales on *Loranthus*; (2) Male and female puparia, magnified.

DIASPINÆ.

This subfamily includes what are known as "armoured scales". The armour or covering secreted by the insect is pretty hard and tough and as such these forms are not easy to destroy. The San Jose Scale, the Mussel Scale and other well-protected species belong to this sub-group. Ants do not generally visit colonies of these scale insects.

CHIONASPIS, Sign.

1. *Chionaspis vitis*, Green. (Pl. I, fig. 1.)

Chionaspis vitis, Green, I. M. N., IV, 1, 1896, p. 3.
Chionaspis vitis, Green, C. of C., Pt. II, 1899, p. 140, pl. XLVII.
Chionaspis vitis, Green, Mem. Dept. Agri., India, Ent. Ser., II, 1908, p. 37.

Habitat. This insect is pretty common in South India. It chiefly attacks mango though it has been noted on *Elæagnus latifolia* on the Nilgiris. It is very commonly found on mango in Bangalore, Kollegal and on the lower slopes of the Nilgiris, chiefly during the summer months. The infested plants show a discolouration of the leaf, the insect turning the natural green to a pale whitish yellow. The female puparia are white and irregularly oval with the pellicles yellowish; the male scales are small and elongate with the pellicle short and pale brownish.

Green has recorded it on *Vitis lanceolaria* and also on *Loranthus* sp. in Ceylon. He observes in that connection that, "Should the grape-vine be ever cultivated largely in Ceylon, this insect might prove a rather serious pest." I have not noted it on grape yet.

2. *Chionaspis dilatata*, Green. (Pl. I, fig. 2.)

Chionaspis dilatata, Green, C. of C., Pt. II, 1899, p. 148, pl. LI.
Chionaspis dilatata, Green, Mem. Dept. Agri., India, Ent. Ser., II, 1908, p. 36.
Phenacaspis dilatata, Cooley, Fern. Cat., p. 237 (the genus *Phenacaspis* was erected by Cooley and Cockerell, *Canadian Entomologist*, XXXV, p. 48).

Habitat. This insect was noted on young Areca palms in the Fern House at the Lal Bagh, Bangalore, in April, and on the leaf-sheaths of the palmyra palm in Godavari (December). Green remarks on specimens on palm leaf-sheath, "These are not typical examples; but

the differences are so small that I do not care to separate them specifically." The snow-white female puparia appear prominent though not in such crowded colonies as in the case of *C. vitis*. The female scales are bright white with the pellicles reddish brown; the male puparium is not distinctly keeled as in *C. vitis*. This is the first record of it in South India. Green records it from Calcutta on a species of palm. Known to infest mango, *Myristica moschata* and *Eurycles*. Noted on *Pandanus odoratissimus* in Australia. Reported to be very common on mango and *Ficus* in Poona.

3. *Chionaspis biclavis*, Comst.

Chionaspis biclavis, Comstock, Second Rept., Dept. Ento., Corn. Uni., 1883, p. 98.
Chionaspis biclavis, Green, I. M. N., IV, 1896, p. 2.
Howardia biclavis, Ber. and Leon., Riv. Pat. Veg., IV, 1896, p. 348.
Chionaspis biclavis, Green, C. of. C., Pt. II, 1899, p. 152, pl. LIV.
Chionaspis biclavis, Green and Mann, Mem. Dept. Agri., India, Ent. Ser., I, 1907, p. 354.
Chionaspis biclavis, Green, Mem. Dept. Agri., India, Ent. Ser., II, 1908, p. 36.
Chionaspis biclavis, Newstead, Mon. Br. Cocc., I, 1901, p. 190, pl. XXI.
Chionaspis biclavis, Fletcher, Some South Indian Insects, 1914, p. 519, fig. 410.

Habitat. On the tea plant on the Nilgiris; first recorded by Green in 1908. Green remarks that this insect is perhaps "the most serious and widespread of all Coccidæ affecting the tea plant in Ceylon." It has not yet come to such prominence in South India. The species burrows into the bark and becomes more or less hidden; this is popularly called "the mining scale." The female scales are found concealed under the fibres of the bark of the host plant; males are unknown. It has been observed on cinchona, coffee and *Grevillea* in Ceylon, and on many other plants in other countries. I have not seen this insect.

4. *Chionaspis varicosa*, Green. (Pl. I, fig. 3.)

Chionaspis eugeniæ, var. *varicosa*, Green, I. M. N., I, 1896, p. 2.
Chionaspis varicosa, Green, C. of C., Pt. II, p. 146, pl. L, 1899.
Phenacaspis varicosa—Generic name changed by Cooley, 1902.

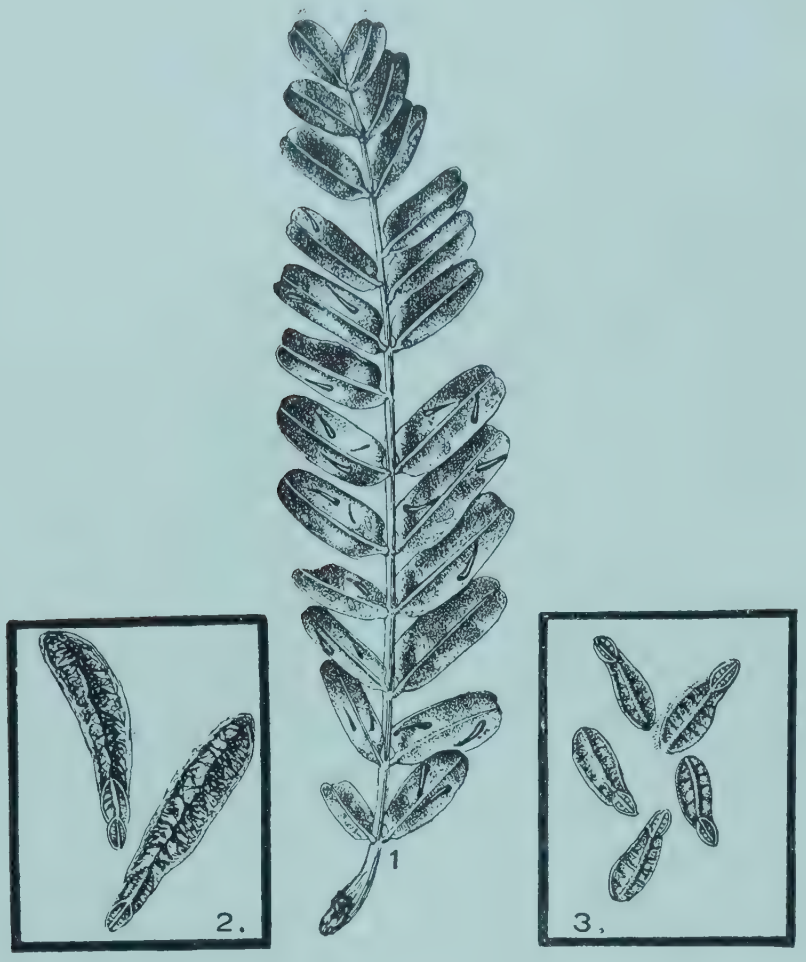


Fig. 4. *Chionaspis acuminata*, Green.
(1) Scales on tamarind leaves; (2) and (3) Puparia, magnified.

Fig. 6. *Fiorinia plana*, Green M.S.
(1) Infested leaves of *Elæodendron*;
(2) Scales, magnified.

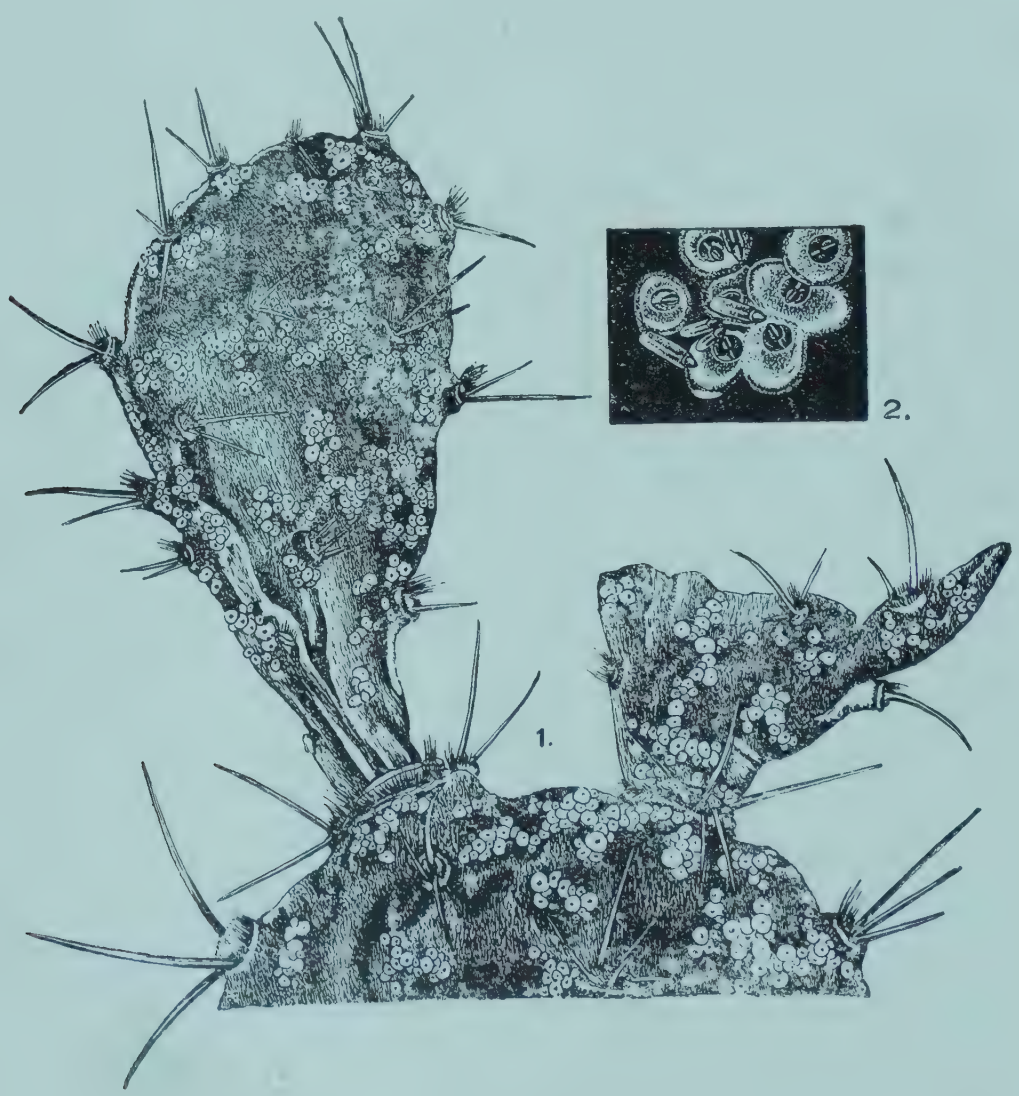


Fig. 5. *Diaspis echinocacti*, Bouché.
(1) Scales on prickly pear; (2) Male and female puparia, magnified.

Habitat. On pepper stem, Sidapur, Coorg (May). The female scales are bright white and roundish in shape. The species is very close to *C. biclavis*, differing only in its slightly longer form and in some minute details. It has not been recorded from India before. Green remarks that the puparium of the scale in the material I submitted to him is not typical, but the narrow form is probably consequent upon the position of the insect on the slender stem of the plant. Green found this on *Gelonium lanceolatum* in Ceylon.

5. *Chionaspis nilgirica*, Green MS.

Habitat. This insect is quite common on *Loranthus* on the Nilgiris at high elevations, 7,000-8,000 feet. Female puparia white, irregularly oval, pellicles yellowish, male scales small, white and tricarinate. Male scales are found crowded together in colonies. The leaves are often completely covered by the clear white male and female scales. *Loranthus*, parasitic on blue gum, *Litsea* and other trees at Ootacamund, are commonly found infested with this species. Badly-covered leaves are found in numbers on the ground below these trees.*

6. *Chionaspis spiculata*, Green MS.

Habitat. On bamboo leaf; Peria pass, Malabar.

7. *Chionaspis acuminata*, Green. (Pl. II, fig. 4.)

(C. of C. Pt. II, p. 136, 1899.)

Habitat. On *Evodia*, Peria pass, Malabar. On *Bassia*, Madura.

C. acuminata, var. *atricolor*, Green.

Noted on *Carissa*, Coimbatore.

Species of *Chionaspis* have also been noted on *Morinda tinctoria* (Madras) and *Ficus* (Penukonda), but the specific determination has not been made due to insufficient material.

DINASPIS, Leon.

8. *Dinaspis permutans*, Green.

Chionaspis permutans, Green, C. of C., II, p. 130, 1899.

Habitat. On *Evodia*, Peria pass, Malabar.

* Mr. Green has very recently written to me that this species is only *Ch. varicosa*, Gr.

DIASPIS, Costa.

9. *Diaspis rosæ*, Bouché.

Aspidiotus rosæ, Bouché, Naturg. Ins., p. 14 (1834).
Diaspis rosæ, Signoret, Ann. Soc. Ent., Fr., IX, 1869, p. 441.
Aulacaspis rosæ, Cockerell, Bull. Bot. Dept., Jamaica, 1896, p. 259.
Aulacaspis rosæ, Newstead, Mon. Br. Cocc., I, 1901, p. 168, pl. XIV.

Habitat. Found on mango leaves and on a wild undetermined plant in Bangalore, March-April. The female scales oval and cream white in colour with the exuviæ dull yellowish. Not previously noted in India though recorded from Europe, America, China, Japan, and Australia on various fruit trees.

10. *Diaspis echinocacti*, Bouché. (Pl. II, fig. 5.)

Aspidiotus echinocacti, Bouché, Schädl. Gart. Ins., p. 53 (1833).
Diaspis calyptroides, Signoret, Ann. Soc. Ent., Fr., 1869, pp. 99 and 434.
Diaspis calyptroides, Newstead, T. E. S., 1897, p. 94.
Diaspis calyptroides, Newstead, Mon. Br. Cocc., 1901, p. 159, pl. XIII, XVI, and XVIII.
Diaspis calyptroides, I. M. N., IV, 4, 1899, p. 211. See also Mem. Dept. Agri., India, Ent. Ser., II, 1908, p. 36.

Habitat. On prickly pear, Coimbatore and other places. This species was first noted in India from specimens sent from South India to the Indian Museum, Calcutta, and these were identified by Mr. Maskell. The species is very common in South India ; sometimes the host plant is completely covered up by this insect. It does not, however, play any very effective part in checking the spread of the weed. The female scale is oval and greyish brown with a brown apex.

11. *Diaspis barberi*, Green.

Diaspis barberi, Green, Mem. Dept. Agri., India, Ent. Ser., II, 1908, p. 35.

Aulacaspis barberi, Rutherford, Spol. Zeyl., X, 1915, p. 110.

Habitat. On *Loranthus;* Alamanda, Vizagapatam District. On mango ; Hadagalli, Bellary. First described from specimens collected by Barber in Tanjore District. It differs slightly from *D. amygdali* of Green.

12. *Diaspis mangiferæ*, Green.

Habitat. On mango leaf ; Alamanda, Vizagapatam District. The female puparia are irregularly oval and have a pale greyish white colour ; the exuviæ, of a dark brown colour. I am unable to find any previous reference to this species.

HEMICHIONASPIS, Ckll.

13. *Hemichionaspis dracænæ*, Cooley.

Hemichionaspis dracænæ, Cooley, Spec. Bull. Mass. Expt. Stn., 1899, p. 57.

Habitat. On Areca palm, Vadanapalle, South Malabar, in October. Young fronds are badly infested, the pale brown puparia being found in patches especially near the stalk and proximal portion of the leaf ribs. Not noted before in India. Described from Socotra.

14. *Hemichionaspis aspidistræ*, Sign.

Chionaspis aspidistræ, Signoret, Ann. Soc. Ent., Fr. (4), IX, 1869, p. 443.
Chionaspis aspidistræ, Cotes, I. M. N., II, 1891 p. 17.
Chionaspis brasiliensis, Maskell, I. M. N., III, 5, 1894, p. 52.
Chionaspis aspidistræ, Green, C. of C., Pt. II, 1899, p. 110, pl. XXXII.
Chionaspis aspidistræ, Newstead, Mon. Br. Cocc., I, 1901, p. 187, pl. XX.
Hemichionaspis aspidistræ, Cooley, Bull. Mass. Expt. Stn., 1899, p. 45.
Hemichionaspis aspidistræ, Essig, Pom. Coll. Jour., 1909, p. 310.

Habitat. Found on Areca and jak in Mysore, on pepper berries and leaves in the Western Ghats, on Ceara rubber leaf on the Nilgiris, 2,000 feet, on coconut leaves in Malabar, on *Citrus* leaves in Godavari District, and on *Ficus* leaf in the Coimbatore and Godavari Districts. In some cases male scales are very numerous and prominent, while the female puparia are very few. These latter are long and narrow. The scale widens gradually from the anterior to the posterior end which is widest. The male scales are white in colour, while the female puparia have a pale yellowish to dark brown tinge. On pepper, the white scales predominate and often completely cover the berries like patches of lime. On the rubber leaf the female puparia were more commonly found. These light reddish brown female scales are found generally

on the back of the rubber leaves. This insect is a distinctly injurious species; though it has not assumed pest proportions there is every likelihood of this insect becoming serious as it affects numerous hot house and other plants. It has been noted on a variety of plants in different countries, and in Ceylon, Green records it on ferns, *Acacia*, mango, *Capparis*, *Croton* and many other plants. All the stages are found on *Ficus bengalensis* leaves in September at Kollegal, Coimbatore District. I have also noted a small black Chalcid as a parasite of this insect. A ladybird beetle, *Chilochorus circumdatus*, is said to be a natural enemy of this insect in Ceylon.

15. *Hemichionaspis minor*, Mask.

Chionaspis minor, Maskell, N. Z. Tr., XVII, 1884, p. 33.
Hemichionaspis minor, Cooley, Spec. Bull. Mass. Expt. Stn., 1899, p. 52.
Chionaspis albizziæ, Green, C. of C., Pt. II, 1899, p. 115, pl. XXXIV.
Hemichionaspis minor, De Neciville, I. M. N., V, 3, 1903, p. 128.
Hemichionaspis minor, Green, Mem. Dept. Agri., India, Ent. Ser., II, 1908 p. 39.
Hemichionaspis minor, Townsend, Jour. Ec. Enty., 1912, p. 256.

Habitat. Noted on the leaf-sheaths of *Agave* in Cuddappah, on leaves of *Cassia tora* and *Diospyros chloroxylon* in Bellary, and on leaf and fruit of tamarind in Coimbatore. The female puparia are brownish white in colour and in general form more or less similar to *H. aspidistræ*. This is also an insect which is likely to become a pest in course of time, as it has been noted to be a destructive species in other countries. An infested young *Cassia* plant, with the exception of the tender shoots and leaves, is literally covered with the pale brown and white scales of this insect. Two wasps, *Prospaltella berlesei* and *Aphelinus diaspidis*, are parasitic on this scale in Ceylon. The ladybird beetle *Chilocorus nigrita*, Fab., is said to be predaceous on this insect in Calcutta, but I have not noted it as yet. This Coccid is known as the white scale (Piojo blanco) of cotton in Peru.

Recorded on cotton, pepper, coconut, etc., in other countries. It has been noted before on sann-hemp in Sibpur, Calcutta.

Mr. Green doubts whether the forms noted on tamarind and *Agave* sheath belong to this species. From one specimen I have recently collected on tamarind leaf at Coimbatore I am also led to believe that the tamarind ones may be a different species altogether. The female puparium looks quite different from *H. minor*.

16. *Hemichionaspis theæ*, Mask.

Chionaspis theæ, Maskell, I. M. N., II, 1891, p. 60, pl. I, fig. 2 *a-c*.
Chionaspis theæ, Cotes, I. M. N., II, 6, 1893, p. 168.
Chionaspis theæ, Cotes, I. M. N., III, 1, 1893, p. 25.
Chionaspis theæ, Cotes, I. M. N., III, 4, 1895, p. 39.
Chionaspis exercitata, Green, I. M. N., IV, 1896, p. 3.
Chionaspis theæ, Green, C. of C., Pt. II, 1899, p. 113, pl. XXXIII.
Chionaspis theæ, Watt and Mann, Pests and Blights of Tea, 1903, p. 307.
Hemichionaspis theæ, Cooley, Spec. Bull. Mass. Expt. Stn., 1899, p. 51.
Hemichionaspis theæ, Green and Mann, Mem. Dept. Agri., India, Ent. Ser., I, 1907, p. 342 ; Fletcher, South Ind. Ins., pp. 520-521, f. 411.

Habitat. A few male puparia on pomegranate leaves found at Coimbatore and forwarded to Mr. Green were identified as probably belonging to this species. Female puparia long and narrow with sides more or less parallel ; these are generally not very conspicuous. Male scales white and tricarinate. These latter are disposed in regular groups. So far, there is no definite record of its occurrence in South India, though Watt and Mann state that it is found in all tea districts in India. It is quite possible that it may be found to occur in the tea districts of South India, since it has been found on the Himalayas on one side and Ceylon on the other. This is not said to be a pest of any importance in South India. Recently I have come across specimens of male puparia on pepper and some wild plants on the Western Ghats, which by their general form and nice arrangement in groups appear to me to belong to this species.

17. *Hemichionaspis chionaspiformis*, Newst.

Diaspis (?) *chionaspiformis*, Newstead, Bull. Ent. Res., I, 3, 1910, p. 198.
Hemichionaspis chionaspiformis, Lindinger, Jahrb. Hamb. Wiss. Anst., 1910, p. 43.

Habitat. On wild indigo, Coimbatore. Recorded before from Africa ; female puparia white with reddish yellow pellicles. Male scales small and white. No previous record from India.

FIORINIA, Targ.

18. *Fiorinia plana*, Green MS. (Pl. II, fig. 6.)

Habitat. Noted on the leaves of *Elæodendron glaucum*, Coimbatore and Courtallum (Tinnevelly). The green leaves affected by the

insect show a yellowish brown dust-coated appearance. At a distance badly affected leaves show an ash-coated white appearance. Mr. Green is publishing the scientific description of the species separately. The insect is found on the tree throughout the year. It is allied to *F. similis*, Green.

ASPIDIOTUS, Bouché.

19. *Aspidiotus destructor*, Sign. (Fig. 7.)

Aspidiotus destructor, Signoret, Ann. Soc. Ent., Fr., 1869, p. 120.
Aspidiotus destructor, Maskell, I. M. N., III, 1, 1893, p. 66.
Aspidiotus destructor, Green, B. J., XIII, 1900, p. 70.
Aspidiotus destructor, Fletcher, South Ind. Ins., p. 518, f. 408.

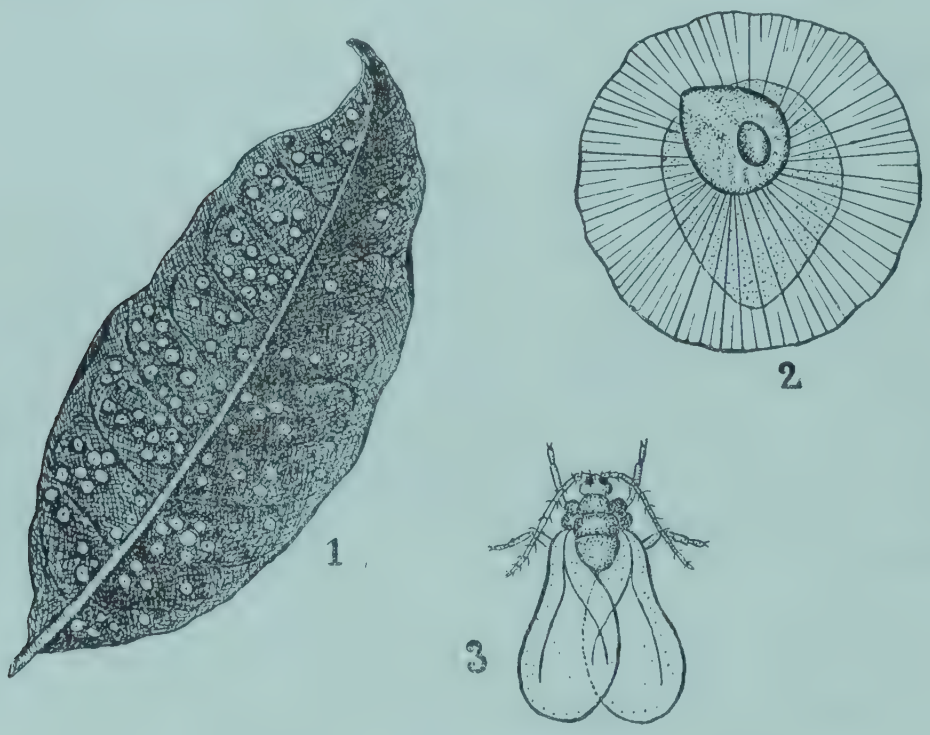


Fig. 7. *Aspidiotus destructor*, Sign.
(1) Scales on leaf, natural size; (2) Female, and (3) Male, both magnified. (After Green.) (From *South Ind. Ins*, fig. 408.)

Portions of Green's descriptions of the two species *A. lataniæ* and *A. transparens* in his "Coccidæ of Ceylon" refer to this species.

Habitat. Found on coconut all over the West Coast, Tinnevelly, Coimbatore and Anantapur. Noted on *Eugenia* in the Mysore uplands. It was first noted on coconut from the Laccadives in 1891. The puparia are semi-transparent, yellowish, irregularly circular, and are found in large patches on infested fronds. Kasergode and Burkill record this on mango in Bombay. It has been

recorded also on tea, pepper, Ceara rubber, plantain leaf, *Loranthus*, etc., in Ceylon. Sometimes the insect causes appreciable damage to the coconut palm. The species has a very wide distribution, being found in China, Australia, Mexico, West Indies, etc.

20. *Aspidiotus orientalis*, Newst.

Aspidiotus orientalis, Newstead, I. M. N., III, 5, 1894, p. 26.

Aspidiotus osbeckiæ, Green, I. M. N., IV, 1896, p. 4.

Aspidiotus osbeckiæ, Green, C. of C., Pt. I, 1896, p. 47, pl. VII.

Aspidiotus orientalis, Green, B. J., XIII, 1900, p. 69.

Aspidiotus orientalis, Rutherford, Spol. Zeyl., X, 1915, p. 106.

This species was first described by Professor Newstead from specimens collected by Miss Tomlin at Seven Pagodas near Madras in 1892. The food-plant on which it was found is not stated. This insect is very commonly found on a variety of plants in South India. The puparia are compact and oval, varying in colour from light to reddish brown ; the central pellicles are reddish ; the male scales are oblong. On tamarind fruits the scales are found in enormous numbers in patches covering the whole fruit and giving it a sickly corrugated appearance. It has been so far noted on castor, *Solanum*, *Tephrosia*, *Cassia*, *Polyalthia*, plantain leaf, *Calotropis*, tamarind, *Chloroxylon swietenia*, mahogany, *Carissa*, etc. It is recorded on banana leaves and on leaves and fruits of papaya in Australia, on *Atylosia candollei* and *Osbeckia* in Ceylon and on rose plant in Bombay.

21. *Aspidiotus lataniæ*, Sign.

Aspidiotus lataniæ, Signoret, Ann. Soc. Ent., Fr., 1869, p. 124.

Aspidiotus lataniæ, Green, B. J., XIII, 1900, p. 69.

Aspidiotus lataniæ, Green, Mem. Dept. Agri., India, Ent. Ser., II, 1908, p. 33.

Green states that his *cydoniæ* recorded in his C. of C. is the true *lataniæ*, Sign.

Habitat. Noted on sisal hemp and *Carissa carandas* in Coimbatore and on *Nerium oleander* in Madras. The female puparia are strongly convex and circular ; pale brown in colour. It has been recorded before on peach in Coonoor and *Phœnix* in Calcutta. In Bombay it is noted on *Citrus*, bamboo and *Poinciana regia*.

22. *Aspidiotus rossi*, Mask.

Aspidiotus rossi, Maskell, N. Z. Transactions, XXIII, 1890, p. 3.
Aspidiotus rossi, Green, C. of C., Pt. I, 1896, p. 45, pl. VI.
Chrysomphalus rossi, Leonardi, Riv. Pet. Veg., VII, 1899, p. 202.
Chrysomphalus rossi, Rutherford, Spol. Zeyl., X, 1915, p. 107.

Habitat. Found on mango leaves, Cocanada, and on *Carissa carandas* leaves in Coimbatore. Not very common. The puparia are oval in shape and are dark brown in colour, the central region being almost black. Noted on *Barringtonia acutangula* at Poona by Kasergode. Found on *Cycas* sp. and on *Capparis* in Ceylon. The original home of this species appears to be Australia, where it is very common and affects a variety of plants.

23. *Aspidiotus cyanophylli*, Sign.

Aspidiotus cyanophylli, Signoret, Ann. Soc. Ent., Fr., IX, 1869, p. 119.
Aspidiotus cyanophylli, Newstead, Mon. Br. Cocc., I, 1901, p. 124, pl. IX.
Aspidiotus cyanophylli, Green, C. of C., p. 51, pl. IX.

Habitat. On plantain leaf and Ceara rubber, Nilgiris, 2,000 feet. Female puparia pale yellowish and transparent, oblong or roughly oval in shape. Not recorded before from India. Green records it on tea, a species of palm, and cinchona in Ceylon. Noted on plantain (*Musa*) in Fiji. (See *Bull. Ent. Res.*, V, 1, p. 44, 1916). It is recorded on coconut husk in Zanzibar.

24. *Aspidiotus camelliæ*, Sign. (Fig. 8.)

Aspidiotus camelliæ, Signoret, Ann. Soc. Ent., Fr., IX, 1869, p. 117.
Aspidiotus flavescens, Green, I. M. N., II, 6, 1893, p. 168.
Aspidiotus flavescens, Green, I. M. N., III, 4, 1895, p. 41.
Diaspis circulata, Green, I. M. N., IV, 1, 1896, p. 4.
Aspidiotus camelliæ, Green, C. of C., Pt. I, 1896, p. 60, pl. XIII.
Aspidiotus camelliæ, Green, B. J., XIII, 1900, p. 71.
Aspidiotus camelliæ, Watt and Mann, Pests and Blights of Tea, 1903, p. 303.
Aspidiotus camelliæ, Green and Mann, Mem. Dept. Agri., India, Ent. Ser., I, 1907, pp. 343 and 353.
Aspidiotus camelliæ, Newstead, Mon. Br. Cocc., I, 1900, p. 91.
Aspidiotus camelliæ, Newstead, Bull. Ent. Res., VII, 1917, p. 371.
Aspidiotus camelliæ, Fletcher, South Ind. Ins., pp. 517-518, f.407.

Fig. 9. *Aspidiotus cydoniæ*, Comst.
(1) Scales on grape-vine, (2) Puparium, magnified.

Fig. 10. *Aspidiotus tamarindus*, Green M.S.
(1) Scales on leaves of tamarind ; (2) Scales, magnified.

Fig. 11. *Aspidiotus pseudocamelliæ*, Green M.S., *on Capparis.*

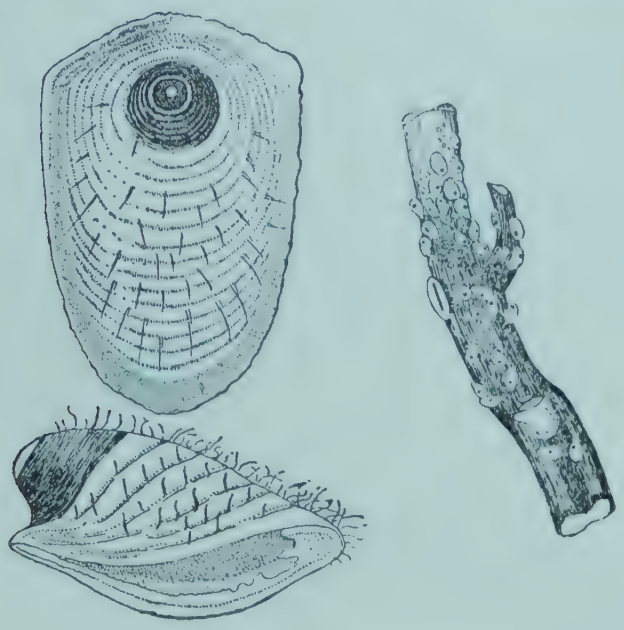


Fig. 8. *Aspidiotus camelliæ*, Sign.
Scales, natural size, on branch, and two scales, magnified, seen from above and from the side. (After Green.) (From *South Ind. Insects*. fig. 407.)

Habitat. On tea in the Nilgiris. It was also found bad on a young English elm tree in the Ootacamund Botanical Gardens and also on a species of *Ficus* at Dodabetta, 7,500 feet ; May 1917.

This is called " the yellow bark louse " of tea ; is also called " the greedy " scale in other countries. The puparia greyish white in colour, oval and strongly convex, each looking like a limpet in shape. Sometimes found crowded together in patches. Recorded also as common on *Grevillea*, Cinchona, and *Michœlia* in Ceylon.

25. *Aspidiotus cydoniæ*, Comst. (Pl. III, fig. 9.)

Aspidiotus cydoniæ, Comstock, Rept. U. S. Dept. Agri., 1880, p. 295.

[*Aspidiotus cydoniæ* of Green in his Coccidæ of Ceylon, p. 62 (1896), is not that species (*See* B. J., XIII, 1900, p. 71).]

Habitat. Found on grape, fig, and pear plants at Bangalore and Coimbatore.

The scales are small and circular having a pale brown colouring ; found in patches at the nodes of grape-vines and on the stalks of fig and pear fruits and shoots. Likely to become a pest and appears to have been introduced with fruit and nursery stock. This is the first record from India.

26. *Aspidiotus dictyospermi*, Morg.

Aspidiotus dictyospermi, Morgan, Ent. Mon. Mag., XXV, 1889, p. 352.

Aspidiotus dictyospermi, Barlow, I. M. N., IV, 1899, p. 119.

Chrysomphalus dictyospermi, Leonardi, Riv. Pat. Veg., VII, 1899, p. 218.
Aspidiotus dictyospermi, Green, B. J., XIII, 1900, p. 68.
Aspidiotus dictyospermi, Green, B. J., XVI., 1905, p. 345.

Habitat. On *Dendrobium* (Bangalore). The succulent parts of this orchid were found thickly covered by this insect. On *Mimusops elengi* (Cocanada). The flat reddish brown scales are easily made out. Noted before on *Cycas*, *Opuntia*, and *Calophyllum* in Ceylon. Noted on tea in North India. Recorded on rose bushes in Uganda (see *Bull. Ent. Res.*, VII, 1917, p. 271).

27. *Aspidiotus tamarindus*, Green MS. (Pl. III, fig. 10.)

Habitat. On tamarind leaf and fruit (Coimbatore).

The scales are found in company with *Hemichionaspis minor*, Mask. The technical description of this new species is being published by Mr. Green. It is closely allied to *A. hederæ*, Vall., but differs in the large third lobe.

28. *Aspidiotus pseudocamelliæ*, Green MS (Pl. III, fig. 11.)

Habitat. On *Capparis ;* Ittige, Bellary District. The greyish oval scales are found in depressions on the leaf surface. The plant appears to suffer badly from the infestation.

29. *Aspidiotus moorei*, Green.

Aspidiotus moorei, Green, Ent. Mon. Mag., 1896, p. 199.
Targionia moorei, Leonardi, 1900.
Aspidiotus moorei, Green, I. M. N., V, 1900, p. 2.

The species was first described by Mr. Green from specimens got from Madras in 1896. Found on *Grislea tomentosa*. I have not seen specimens of this species.

30. *Aspidiotus aurantii*, Mask. (Pl. IV, fig. 12.)

Aspidiotus aurantii, Maskell, N. Z. Tr., XI, 1878, p. 199.
Aspidiotus aurantii, Green, C. of C., Pt. I, 1896, p. 58, pl. XII.
Aspidiotus aurantii, Green, I. M. N., V, 1, 1900, p. 2.
Chrysomphalus aurantii, Cockerell, Check List Suppl., 1899, p. 396.
Aspidiotus aurantii, Green, B. J., XIII, 1900, p. 71.
Aspidiotus aurantii, Newstead, Mon. Br. Cocc., I, 1901, p. 68, pl. I.

Reference will also be found in numerous American publications in Entomology.

This is the notorious "red scale" of *Citrus* trees in America and other countries.

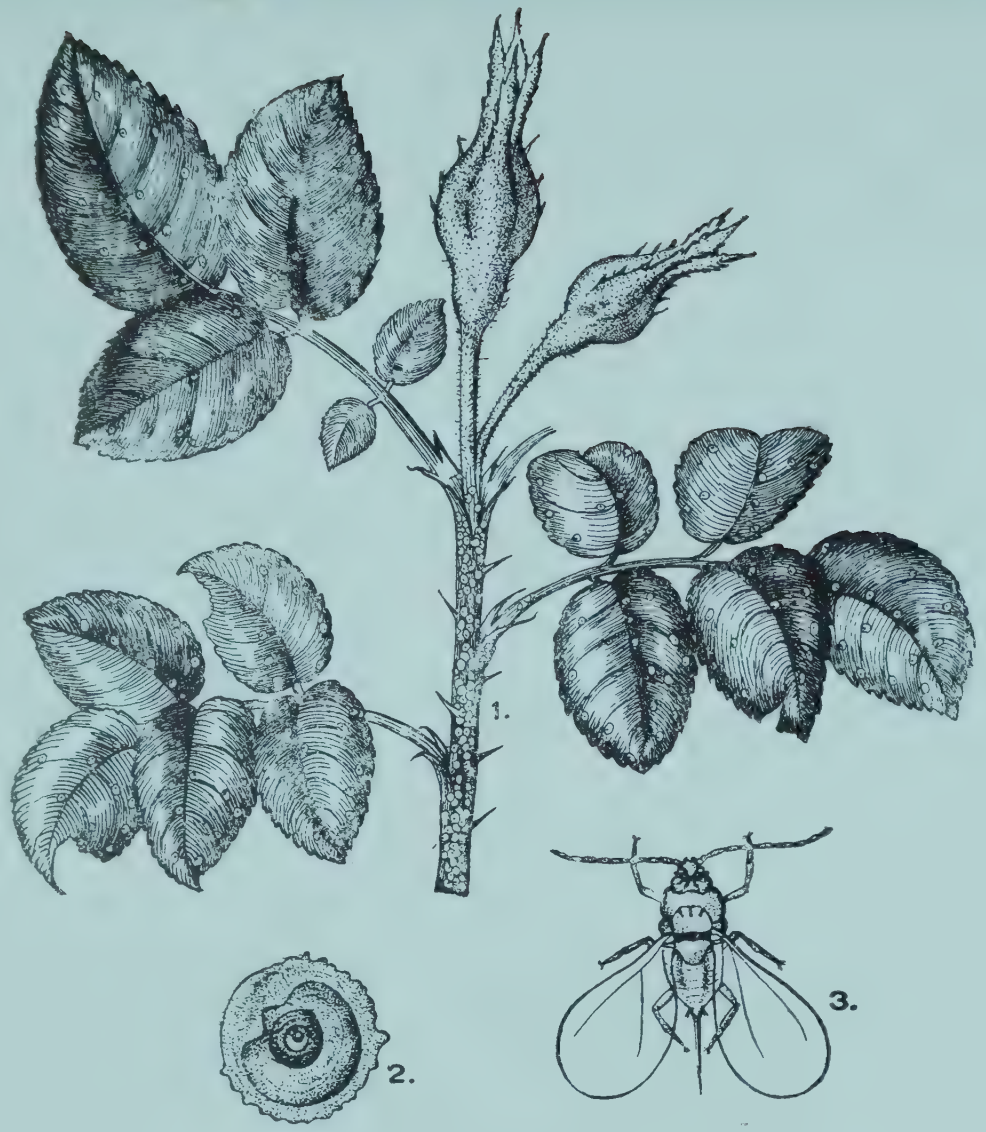


Fig. 12. *Aspidiotus aurantii*, Mask.

(1) Scales on rose shoot; (2) Female puparium, magnified; (3) Adult male, magnified.

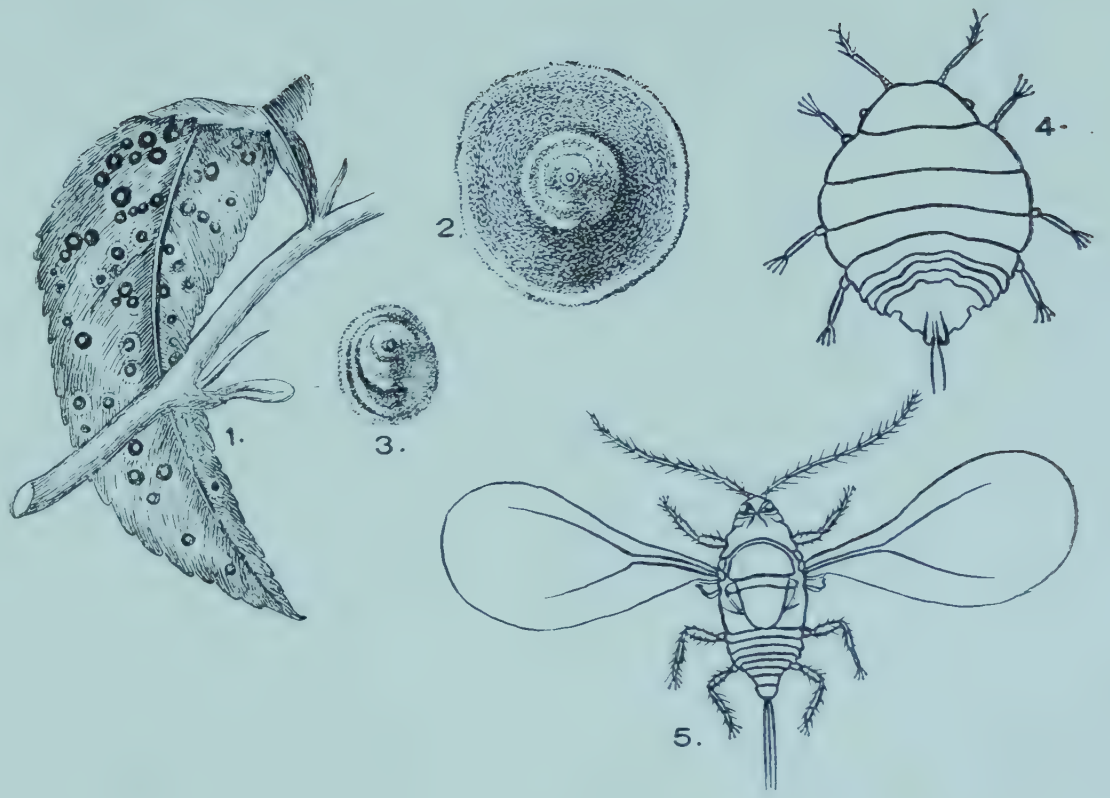


Fig. 13. *Aspidiotus ficus*, Ashmead.

(1) Scales on orange leaf; (2) Female scale, (3) Male scale, (4) Larva, and (5) Adult male, all magnified. (Fig. from *Indian Museum Notes*.)

Fig. 14. *Aspidiotus triglandulosus*, Green, on jak leaf.

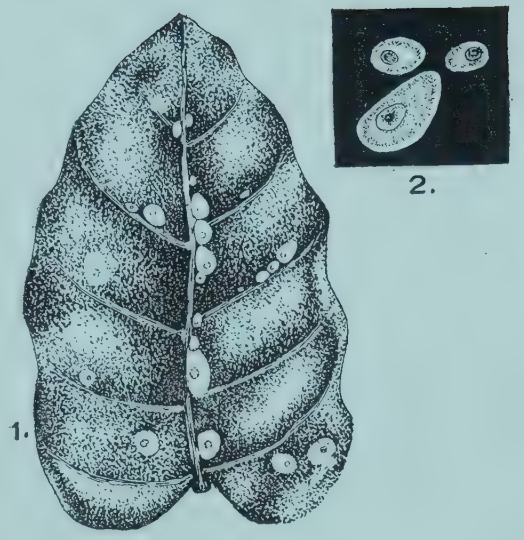


Fig. 15. *Aspidiotus* (*Pseudaonidia*) *trilobitiformis*, Green.

(1) Scales on *Ixora* leaf; (2) Scales, magnified.

Fig. 16. *Gymnaspis ficus*, Green M.S.

Habitat. On rose bush, badly covering leaves and stem, Palghat, Malabar ; Jasmine leaves, Someshwaram, Godavari District. Noted before on rose bushes in North India. I have not seen it yet on a *Citrus* plant in South India, but it is quite likely to be found. Mr. Green has recorded it on *Agave*, pomelo and oranges in Ceylon. This is one of those insects against which *Citrus* cultivators have to be on the guard.

31. *Aspidiotus ficus*, Ashmead. (Pl. IV, fig. 13.)

Chrysomphalus ficus, Ashmead, Amer. Ent., III, 1880, p. 267.
Aspidiotus ficus, Comstock, Rept. U. S. A. Dept. Agri., X, 1881, p. 296.
Aspidiotus ficus, Barlow, I. M. N., IV, 2, 1896, p. 69.
Chrysomphalus aonidium, Cockerell, Biol. Centr. Amer., Pt. II, 1899, p. 25.
Aspidiotus ficus, Green, B. J., XIII, 1900, p. 69.
Aspidiotus ficus, Newstead, Mon. Br. Cocc., Pt. I, 1901, p. 104, pl. I.
Aspidiotus ficus, Green, C. of C., Pt. I, 1896, p. 43, pl. V.
Aspidiotus ficus, Green, Mem. Dept. Agri., India, Ent. Ser., II, 1908, p. 33.

This is also a well-known insect and cosmopolitan in distribution ; recorded on a variety of plants.

Habitat. On *Ficus* (Penukonda, Anantapur District) ; mango (Coimbatore) ; *Citrus* leaf (South Malabar and Nilgiris) ; *Pandanus* (Cochin Coast); and *Eugenia* and *Citrus* (Maddur, Mysore). Noted before from Calcutta on *Phœnix*, and on Areca and orange from Bombay. In Ceylon, Green records it on *Rhododendron arboreum*. It has recently been noted on coconut in S. Kanara. The scales are dark purplish brown in colour with the pellicles reddish.

32. *Aspidiotus triglandulosus*, Green. (Pl. V, fig. 14.)

Aspidiotus (*Chrysomphalus*) *triglandulosus*, Green, Mem. Dept. Agri., India, Ent. Ser., II, 1908, p. 33.

This species was first described by Mr. Green from specimens collected at Mahabaleshwar, Bombay, on an undetermined tree.

Habitat. On jak leaf, Bangaloré. (Fletcher coll.)

The minute bluish-black scales are found regularly arranged along the leaf ribs on both sides of the leaf and its stalk.

33. *Aspidiotus trilobitiformis*, Green. (Pl. V, fig. 15.)

Aspidiotus trilobitiformis, Green, I. M. N., IV, 1, 1896, p. 41.
Aspidiotus trilobitiformis, Green, C. of C., Pt. I, 1896, p. 41, pl. IV.
Aspidiotus trilobitiformis, Green, B. J., XIII, 1900, p. 66.
Pseudaonidia trilobitiformis, Cockerell. A. M N. H., IX 1902. p. 456.

Pseudaonidia trilobitiformis, Rutherford, Spol. Zeyl., X, 1915, p. 108.

Habitat. On *Ixora*, Vadanapalle (South Malabar); on *Mimusops elengi* (Cocanada), on mango (Coimbatore). Noted in Ceylon on *Dalbergia championii* and *Ixora coccinea*, but the ordinary food-plant in Ceylon, according to Green, appears to be *Nothopegia colebrookiana*. Noted on oleander in Africa (Neave). The female puparium is flattish oval and of a pale reddish brown colour. On *Ixora* the scales are generally found clustering along the mid-rib of the leaf. Not noted before in India.

ODONASPIS, Cockerell.

34. *Odonaspis simplex*, Green.

Chionaspis simplex, Green, C. of C., Pt. II, p. 160, 1899.

Habitat. On bamboo stem, Coimbatore. New to India.

35. *Odonaspis penicillata*, Green.

Odonaspis penicillata, Green, B. J., XVI, 1907, p. 346.

Frogattiella penicillata, Rutherford, Spol. Zeyl., X, 1915, p. 104.

Habitat. On bamboo—*Ochlandra travancorica*—Coimbatore. The scales are found at the nodes amongst the plant hairs at that point. The pale brown scales edged with white are generally found protected by the hairs and the small leaf-sheaths at the nodes. First recorded by Green from Ceylon on giant bamboo *Gigantochloa aspera*. New to India.

AONIDIA, Targ.

36. *Aonidia viridis*, Lind.

Aonidia viridis, Lindinger, Zeit. f. wiss. Insekbiol., 1911, p. 66.

Habitat. On *Aglaia* (Travancore). This is a recent record by Lindinger. I have not seen the form myself.

37. *Aonidia tentaculata*, Green MS.

Habitat. On *Vateria indica*, Quilon, Travancore.

GYMNASPIS, Newst.

38. *Gymnaspis ficus*, Green MS. (Pl. V, fig. 16.)

Habitat. On leaves of *Ficus retusa*, Kollegal (Coimbatore, 1,600 feet). The scales are obscure and appear as small pale grey to green roundish dots on the leaf surface; not easily made out on the leaf when casually observed; but infested leaves present a rough pale dusty appearance.

39. *Gymnaspis ramakrishnæ*, Green MS.

Habitat. On *Hemigyrosa scanascens*, Courtallum, Tinnevelly.

MYTILASPIS, Sign. (*LEPIDOSAPHES*, Shimer.)

40. *Mytilaspis piperis*, Green. (Fig. 17.)

(Mem. Dept. Agri, India, Ent. Ser., II, 1908, p. 34; Fletcher, South Ind. Ins., p. 519, f. 409.)

Fig. 17. *Mytilaspis piperis*, Green.
(1) Scales on pepper plant; (2) Female puparium, magnified.

Habitat. Pepper leaves and stem, Western Ghats. First described by Green from specimens collected by C. A. Barber in North Malabar. The pepper plant sometimes appears to suffer badly from this pest. The whole surface of the tender shoots and the stems is fringed with these long narrow scales closely overlapping one over the other. A badly infested stem generally fades and dries up. A scale infested vine is not easily made out as the colour and general appearance resemble almost exactly the corrugated rough surface of a healthy stem. Green places this species as an intermediate form between *citricola* and *gloveri*.

41. *Mytilaspis* (*Lepidosaphes*) *beckii*, Newst.

Aspidiotus citricola, Packard, Guide to Study of Insects, 1869, p. 527.

Mytilaspis citricola, Comstock, U. S. A. Agr. Rept., 1880, p. 321.

Mytilasp's beckii, Cockerell, Proc. Ac. N. Sc. Phil., 1899, p. 275.
Mytilaspis pinnæformis, Newstead, Mon. Br. Cocc., I, p. 204, 1901.

Habitat. On pepper leaf (Trivandrum). Collected by my brother Subramania Ayyar and identified by Professor Newstead. This insect which is known as the " purple scale " has a world-wide distribution and attacks various kinds of fruit trees besides other plants. Noted by Green on *Citrus* fruits and *Toddalia aculeata* in Ceylon. Not recorded before from India.

42. *Mytilaspis* (*Lepidosaphes*) *travancorensis*, Lindinger.
(Zt. f. wiss. Insektenbiol., VII, 4, 1911, p. 127.)

Habitat. Recorded on undersurface of *Aglaia* leaf by Lindinger. I have not seen this form.

43. *Mytilaspis retrusus*, Green MS. (Pl. VI, fig. 18.)

Habitat. On *Litsea whitiana*, Dodabetta, Nilgiris, 8,000 feet. The scales are dirty brown in colour and are found fringed in numbers along the veins of the leaf which they very closely resemble in colour ; found chiefly on the lower surface of the leaves.

44. *Mytilaspis ? pallida*, Green.

Mytilaspis pallida, Green, I. M. N., IV, 1896, p. 5.
Mytilaspis gloveri, Pack., var. *pallida*, Green, C. of C., 1896, p. 85, pl. XXIII.

Habitat. On guava leaf, Ramachandrapur, Godavari District, December. Only a few isolated scales were found on a leaf. Mr. Green has determined simply from one or two scales submitted to him with a query. First record from India.

45. *Mytilaspis* (*Lepidosaphes*) *meliæ*, Green MS. (Pl. VI, fig. 19.)

Habitat. On stem and shoots of Nim tree (*Melia azadirachta*), Coimbatore.

Bad on isolated young plants.

PARLATORIA, Targ.

46. *Parlatoria* (*Euparlatoria*) *orientalis*, Newstead MS.

Described by Professor Newstead from specimens I collected in 1909 on a wild bush, Coimbatore, September. The greenish-white scales are found crowded on the small twigs of the plant.

47. *Parlatoria proteus*, Curtis. (Fig. 20.)

Aspidiotus proteus, Curtis, Gard. Chron., 1843, p. 676.
Parlatoria proteus, Signoret, Ann. Soc. Ent., Fr., 1869, p. 450.

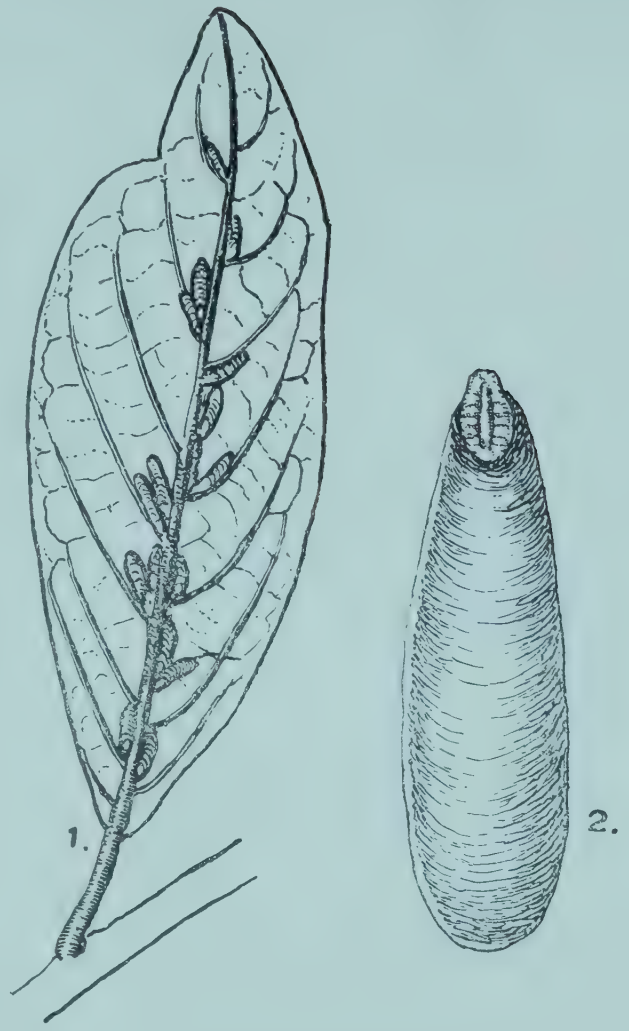


Fig. 18. *Mytilaspis retrusus*, Green M.S.
(1) Scales on *Litsæa* leaf; (2) Female scale, magnified.

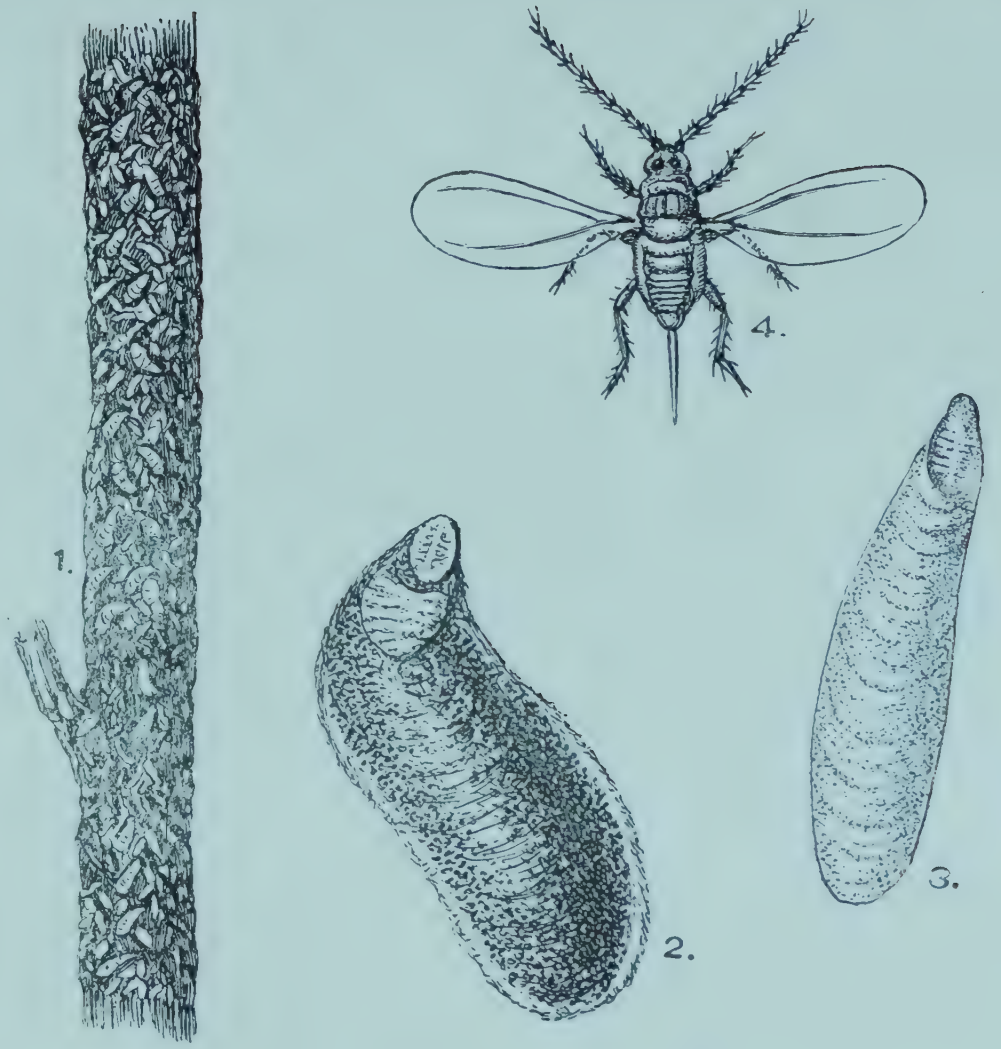


Fig. 19. *Lepidosaphes meliæ*, Green M.S.
(1) Scales on ***Melia*** stem; (2) Full grown female, magnified; (3) Male puparium, magnified; (4) Winged male.

PLATE VI.

Parlatoria proteus, Newstead, Mon. Br. Cocc., Pt. I, 1901, p. 140 pl. XXX.

Parlatoria proteus, Green, B. J., XVI, 1905, p. 349.

Fig. 20. *Parlatoria proteus*, Curtis.

(1) Scales on orchid; (2) Female scales, magnified; (3) Male scales, magnified.

Habitat. On species of orchids—*Vanda* and *Bellatulum*—Lalbagh, Bangalore. The puparia are oval and long and of a dull pale brown colour and found crowded on the leaves of these orchids. This is the first record of the insect in India and it is perhaps an imported form.

48. *Parlatoria pergandii*, Comst.

Parlatoria pergandii, Comstock. U. S. A. Rep., p. 327, 1881.
Parlatoria pergandii, Newstead, Mon. Br. Cocc., I, p. 143, 1901.
Habitat. On garden *Crotons* ; Peria pass, Malabar.

49. *Parlatoria artocarpi*, Green MS.

Habitat. On jak leaf ; Peria pass, Malabar.

50. *Parlatoria* (*Websteriella*) *papillosa*, Green MS.

Habitat. On jak leaf ; Palghat, S. Malabar.

51. *Parlatoria calianthina*, Ber. and Leon.
(Rev. Pat. Veg., III, 1895, p. 346.)

Habitat. The tender leaves, shoots and stems of the garden oleander (*Nerium*), Madras. Once noted before by Lindinger from North India in 1911 (see p. 129 of *Zt. f. wiss. Insekt.*). The insect is found in dirty brown masses on the leaves and shoots in company with colonies of *Aspidiotus lataniæ.*

This is a native of Italy and attacks fruit trees like peach, apple, almond and olive.

I noted this pest only in Madras and though I have examined hundreds of oleander plants in other places I have not yet seen it outside Madras.

52. *Parlatoria* (*Websteriella*) *vateriæ*, Green MS.

Habitat. On *Vateria indica ;* Quilon, Travancore.

53. *Parlatoria* (*Websteriella*) *ziziphus*, Lucas.

Coccus ziziphus, Lucas, Bull. Soc. Ent., Fr., 1853, p. 28.
Parlatoria ziziphus, Signoret, Ann. Soc. Ent., Fr., 1869, p. 451.
Parlatoria ziziphus, Newstead, Mon. Br. Cocc., Pt. I, 1901, p. 148, pl. XXX and XXXIII.
Parlatoria ziziphus, Green, I. M. N., V, 3, 1903, p. 102.

Habitat. On *Citrus* leaves, Coimbatore. The scales are oblong in shape and opaque black with a narrow rim of pale white secretion at the edges. It appears as small black dots on the leaf.

Green records it on *Citrus* ; Ballygunge, Calcutta.

Fig. 21. *Pulvinaria psidii*, Mask.

(1) *Morinda* branch showing colonies of the insect; (2) Female, not mature; (3) Adult female, with ovisac.

Fig. 22. *Ceroplastes actiniformis*. Green, on coconut leaf, magnified.

Fig. 23. *Ceroplastes rubens*. Mask.

(1) Scales on jak leaf; (2) old and (3) young female puparia.

54. *Parlatoria mangiferæ*, Marlatt.

(Bull. U. S. Bur. Ent., t.s. 16, Pt. II, 1908, p. 28.)

Habitat. Found in thick masses on palmyra leaf-sheath, Godavari District. The female puparia are oval and greyish brown with the larval pellicle greenish.

Not recorded before from India. The species was first described by Marlatt in America from specimens received there, as found on mango in Singapore.

55. *Parlatorearum* species (*incertæ sedis*), Lindinger.

Habitat. On *Shorea tanbruggia* from Cuddapah by Lindinger (vide *Zt. f. wiss. Insekt.*, 1911, p. 130).

LECANIINÆ.

The forms included in this and the following sub-families are what are called unarmed scales, where the body is soft and naked or covered over by waxy, cottony or glassy secretion.

PULVINARIA, Targ.

56. *Pulvinaria psidii*, Mask. (Pl. VII, fig. 21.)

Pulvinaria psidii, Maskell, N. Z. Tr., XXV, 1892, p. 223.
Pulvinaria psidii, Green, I. M. N., IV, 1, 1896, p. 8.
Pulvinaria psidii, Green, Mem. Dept. Agri., India, Ent. Ser., II, 1908, p. 32.
Pulvinaria psidii, Green, C. of C., Pt. IV, 1909, p. 264, pl.
Pulvinaria psidii, Fletcher, South Ind. Ins., pp. 510—512, fig. 399.

This is one of the commonest and destructive scale insects of South India. It feeds on a variety of food-plants, the chief of them being guava, mango, *Morinda*, tea and coffee. On guava it is very bad in Coimbatore. Badly infested plants become completely blighted with a dark sooty mould, the leaves showing a glistening sticky appearance due to the sweet secretion produced by these insects. During the early stages and until the female begins to oviposit the insect has a more or less bright green colour and may be mistaken for a green species of *Lecanium*, but after oviposition a long cottony sac is thrown out from behind the female and these white ovisacs proclaim the presence of the pest in badly infested plants. In the planting districts this is very common and is known as " the mealy scale " of coffee and tea.* In the plains, the guava and *Morinda* plants suffer very badly from the attacks of this insect.

* It is wrong to call it a mealy-bug.

57. *Pulvinaria maxima*, Green. (Pl. VIII.)

(Ent. Mon. Mag., XL, 1904, p. 206.)

Habitat. Very common on Nîm (*Melia*) trees in Coimbatore. Sometimes it does considerable damage to young trees. The leathery pale brown adult females cover the tender shoots and stem in numbers, and the small white male scales are generally found conspicuously on the leaves. The ovisacs are prominent and comparatively very long. The ground below badly infested branches of Nîm trees becomes wet with secretion. The common black ant *Camponotus compressus* visits the scales in numbers.

The insect was first described by Mr. Green from Javanese specimens collected on *Erythrina lithosperma*. He speaks of this insect as the giant of its kind. So far in South India it has confined its attacks chiefly to Nîm, but judging from its destructive nature it is not unlikely that it may attack other valuable shade and fruit trees. It has latterly been found on mulberry plants and also on cotton to a small extent in Palur, S. Arcot. Two or three persistent washes with fish oil soap or kerosine emulsion check the pest. A few parasites are found on this insect.

58. *Pulvinaria thespesiæ*, Green.

(C. of C., IV, 1909, p. 259, pl. XCVII.)

Habitat. On *Thespesia populnea* in Coringa (Godavari District) and in Tanjore.

The long curved egg sacs of this insect are very prominent and sometimes cover the foliage profusely. The insect is very much like *Pulvinaria maxima*, and Green who determined the species doubts whether it is really distinct from *Pulvinaria maxima*. This is the first record of the insect in India, Green having described the species for the first time from Ceylon on the same food-plant. The just-hatched larva has a violet brown colour and has two very slender processes at the tail end.

59. *Pulvinaria burkilli*, Green.

(Mem. Dept. Agri., India, Ent. Ser., II, 1908, p. 31.)

Habitat. On shoots of *Zizyphus jujuba*, Coimbatore. (Fletcher coll.)

60. *Pulvinaria obscura*, Newstead.

(I. M. N., III, 5, 1894, p. 23.)

Habitat. Described by Newstead from specimens on *Hygrophila spinosa*, Nungumbakaum Madras.

Collected by Miss Tomlin in 1892.

EXPLANATION OF PLATE VIII.

Pulvinaria maxima, Green.

1. Scale infested *nîm* branch (reduced to $\frac{2}{3}$ of natural size).
2. Adult female mounted on slide, × 7.
3. Adult female from nature, × 7.
4. Male puparium on leaf, × 14.
5. Young active larva, × 20.
6. Adult male, × 20.
7. Predaceous Coccinellid beetle, × 20.

PULVINARIA MAXIMA, GREEN.

Pulvinaria spp.

I have also got imperfect and undetermined material of *Pulvinaria* collected on *Lantana* (Saidapet, Madras), *Myrabilis* (Coimbatore), grape-vine (Salem District), *Strychnos nuxvomica* (Cuddapah District), etc. These will have to be specifically determined in course of time.

CEROPLASTES, Gray.

The species of this genera are known as " Wax scales " due to the soft waxy secretion covering the insects.

61. *Ceroplastes ceriferus*, Anderson.

Coccus ceriferus, Anderson, Monograph Cocci Ceriferi., 1791.
Ceroplastes ceriferus, Signoret, Ann. Soc. Ent. Fr. (2), VI, 1872, p. 40.
Ceroplastes ceriferus, Atkinson, I. M. N., I, 1890, p. 89.
Ceroplastes ceriferus, Stebbing, Ind. Forester, XXI, 1895, p. 328.
Ceroplastes ceriferus, Newstead, I. M. N., III, 5, 1896, p. 21.
Ceroplastes ceriferus, Green, C. of C., Pt. IV, 1909, p. 270, pl. CII.

Habitat. On Indian elm and *Lawsonia alba* (Coimbatore), on *Boswellia* (Tanjore). This insect was first noted at Madras on *Celastrus ceriferus* by Dr. Anderson. It has been recorded later on *Asclepiadron* from Madras and on spp. of *Terminalia* and *Buchanania* in the Central Provinces. This is the white wax insect of India (see *I. M. N.*, II, 3, 1891). The presence of this insect on a plant is easily made out. The mature insect resembles irregular masses of pale white wax or baker's dough attached to the leaves and shoots.

62. *Ceroplastes actiniformis*, Green. (Pl. VII, fig. 22.)

Ceroplastes actiniformis, Green, I. M. N., IV, 1, 1896, p. 8.
Ceroplastes actiniformis, Green, C. of C., Pt. IV, 1909, p. 275, pl. CIV.
Ceroplastes actiniformis, Kasergode, B. J., XXIII, 1914, p. 136.

Habitat. On coconut leaves (Coimbatore, Malabar), mango (Coimbatore), *Canna* (Samalkota, Godavari District), *Ficus* (Penukonda, Anantapur District), *Calophyllum* (South Kanara District). Noted on *Loranthus* and banyan in Poona, and on coconut and other palms, *Canna* and *Sapium* in Ceylon. The insect has a thick waxy spherical test ; the marginal area is divided into 8 portions which enclose a central cone-shaped area. The colour is pale white. I have occasionally found colonies of this scale, young and mature, along the folded

inner surface of the leaves of the coconut palm ; but the insect does not appear to be very destructive to the plant. On *Calophyllum* it was once found pretty bad ; the leaves were covered with colonies of scales and sooty mould.

63. *Ceroplastes rubens*, Mask. (Pl. VII, fig. 23.)

Ceroplastes rubens, Maskell, N. Z. Trans., XXV, 1892, p. 214.
Ceroplastes rubens, Green, I. M. N., V, 1, 1900, p. 8.
Ceroplastes rubens, Green, Mem. Dept. Agri., India, Ent. Ser., II, 1908, p. 32.
Ceroplastes rubens, Green, C. of C., Pt. IV, 1909, p. 273, pl. CIII.

Habitat. On mango (Chicacole), palm, *Cycas revoluta* (Cocanada), *Calophyllum* (Coimbatore), and jak (Palghat). The waxy covering of the insect has a pinkish colour and there are a few marginal narrow bands of white. The insect is popularly called the " The Red Wax Scale " and it is generally found along the ribs of the leaf. Previous record in India was from Assam. In Ceylon, Green records it on tea, mango, *cinnamon*, *Eugenia*, etc.

64. *Ceroplastes floridensis*, Comst.

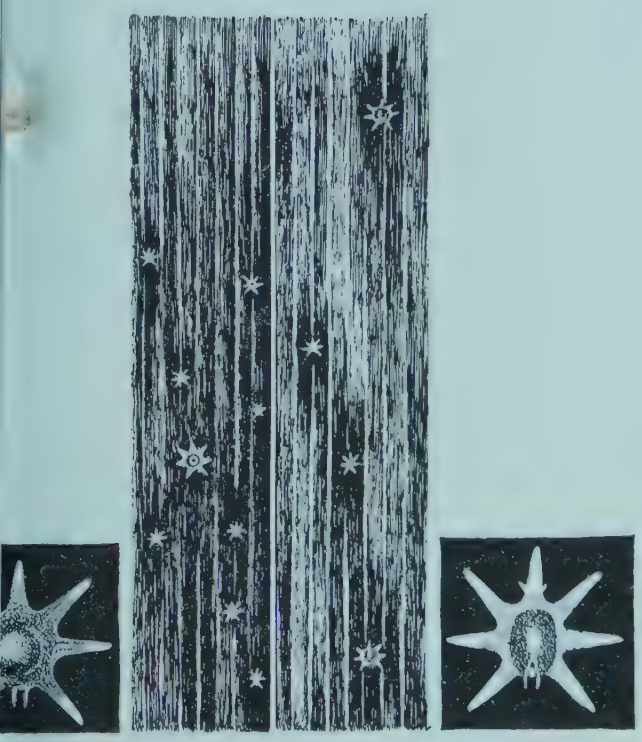
Ceroplastes floridensis, Comstock, Rept. U. S. A. Dept. Agri., 1880, p. 331.
Ceroplastes floridensis, Green, I. M. N., V, 1, 1900, p. 8.
Ceroplastes floridensis, Green, C. of C., Pt. IV, 1909, p. 277, pl. CV.

Habitat. On leaves of cashew (*Anacardium occidentale*), Bangalore, and on *Michœlia*, Courtallum, Tinnevelly District. The waxy test is more or less similar to *rubens* but can be distinguished by the recurved edges of the same and the eight pale white spots on the margin instead of the four narrow bands of *rubens*. Previous Indian record from Assam and Darjiling. Green records it on tea and guava in Ceylon. Noted on numerous other fruit trees in America. My Assistant Mr. Isaac recently noted this species on tea in Travancore.

VINSONIA, Sign.

65. *Vinsonia stellifera*, Westw. (Pl. IX, fig. 24.)

Coccus stellifera, Westwood, Pr. Ent. Soc., Lond., 1871, pp. 3 and iii.
Vinsonia stellifera, Douglas, Ent. Mon. Mag., XXV, 1888, p. 152.
Vinsonia stellifera, Green, C. of C., Pt. IV, 1909, p. 280, pl. CVI.



24. *Vinsonia stellifera*, Westw., on coconut leaf.

Fig. 25. *Inglisia chelonioides*, Green.
(1) Scales on *Parkinsonia* plant; (2) Female scale, magnified.

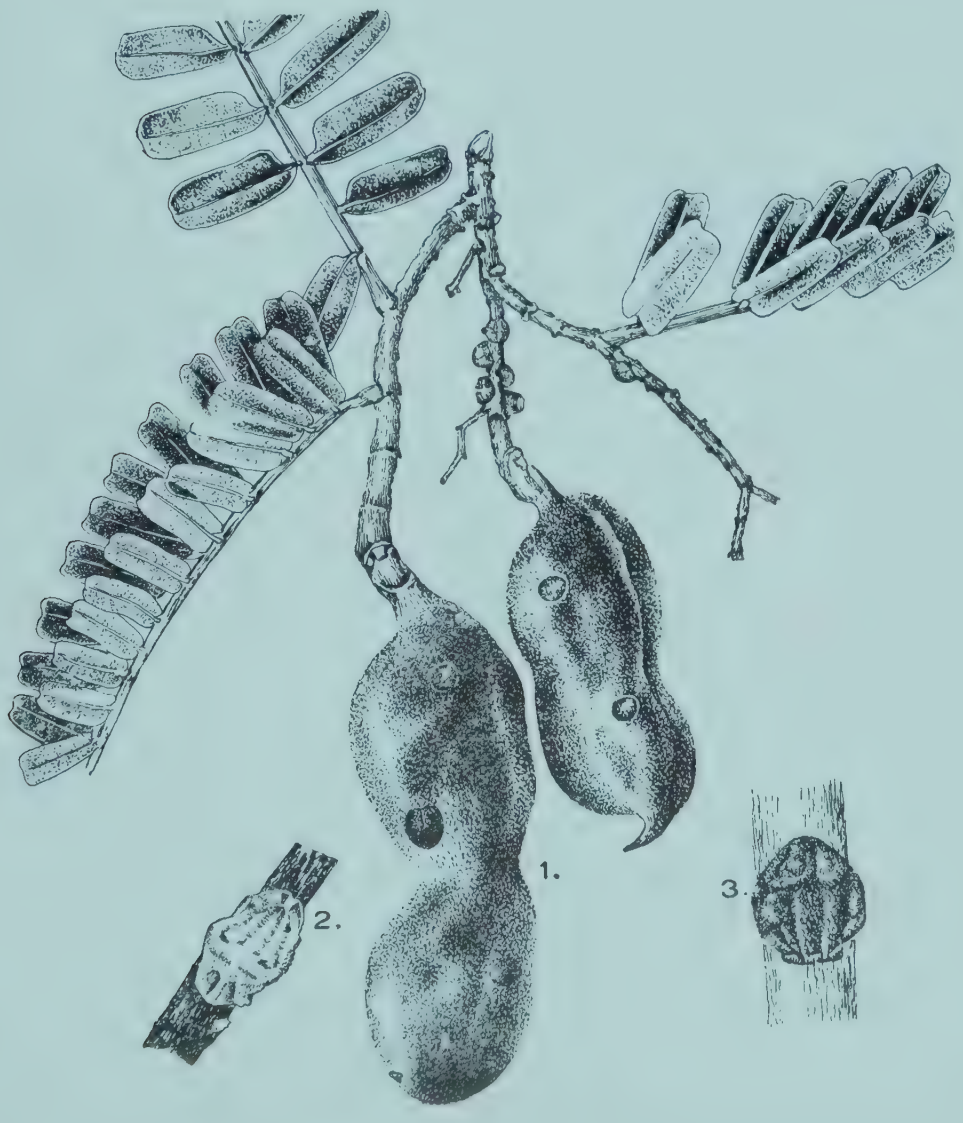


Fig. 26. *Lecanium oleæ*, Ber.

Habitat. On mango (Coimbatore), on nutmeg leaves (Tinnevelly) on coconut palm (Malabar), and on rose-apple leaves *Eugenia jambos* (Godavari District). Along the South Malabar coast, I found this pretty insect fairly common on the coconut palm ; but I did not note it doing any appreciable damage like *Aspidiotus destructor*, though often found in company with it. The waxy secretion in this insect is drawn out radially into seven ray-like projections which give it the appearance of a star-fish. Very recently it has been reported to be very common on rose-apple in Porto Rico. Green notes it on mango, coconut, etc., in Ceylon. Recorded from Bombay on *Garcinia indica.*

INGLISIA, Maskell.

66. *Inglisia chelonioides*, Green. (Pl. IX, fig. 25.)

(C. of C., Pt. IV, 1909, p. 283, pl. CVII.)

Inglisia chelonioides, Gr., Ramakrishna Ayyar, B. J., XXIV, 1916, p. 378.

Habitat. On *Parkinsonia aculeata*, Coimbatore. The species was first described by Green from a single example he got on a small twig of *Gelonium lanceolatum* in Ceylon. I found the insect in fairly good numbers on *Parkinsonia* and sent some specimens to verify whether they belonged to this species. In confirming my determination, Mr. Green wrote, " I am delighted at the possession of further material of this beautiful species and am very interested to find that my prediction as to the thorny habitat of the insects has proved to be correct." The scales very closely resemble the thorns on its food-plant and their presence could be made out only by close observation. The insect is covered by a cone-shaped glassy test and the same seen through the test has a brownish colour. Immature insects are uniform white. A small Chalcidid parasite has been noted attacking this insect. Not recorded before from India.

67. *Inglisia bivalvata*, Green.

(I. M. N., V, 3, 1903, p. 95.)

Habitat. Described by Green from specimens collected on *Thespesia populnea* in Rameswaram island, 1903.

I collected a solitary specimen on red-gram stem at Mandepetta in Godavari District in December 1916. The insect hardly appears a living thing. The body of the insect is covered over by " two glassy shell-like plates meeting along the median longitudinal line." (See Lefroy, *Indian Insect Life*, fig. 529.)

CEROPLASTODES, Ckll.

68. *Ceroplastodes cajani*, Mask.

Eriochiton cajani, Maskell, I. M. N., II, 1891, p. 61.
Ceroplastodes cajani, Cockerell, Nature, LXI, 1900, p. 368.
Ceroplastodes cajani, Green, C. of C., Pt. IV, 1909, p. 285, pl. CVIII
Ceroplastodes cajani, Fletcher, South Ind. Ins., p. 512, f. 400.

Habitat. On red-gram (Coimbatore and Godavari), on lablab vine and *Zizyphus* shoots (Coimbatore), also found on the sacred *Tulsi* plant (*Ocimum sanctum*) in many places. On the main vines of lablab the insect is found in shining white masses often considerably weakening the growth of the vine. The test is glassy and oval in shape with a rugose surface. A species of *Eublemma*—a Noctuid caterpillar—is predaceous on the scale. The species was first described by Maskell from specimens collected on red-gram from Madras in 1891. Very often *Tulsi* plants are killed outright by the attacks of this insect.

LECANIUM, Burmeister.

69. *Lecanium nigrum*, Nietn.

Lecanium nigrum, Nietner, Enemies of Coffee Tree, 1861, p. 9.
Lecanium nigrum, Green, I. M. N., I, 2, 1889, p. 117.
Lecanium nigrum, Cotes, I. M. N., II, 6, 1893, p. 168.
Lecanium nigrum, Green, C. of C., 1896, p. 229, pl. LXXXIV.
Saissetia nigra, King, Psyche, IX, 1902, p. 296.
Coccus nigrum, Kirkaldy, Faun. Haw., Pt. III, 1902, p. 106.
Lecanium nigrum, Fletcher, South Ind. Ins., pp. 514-515, f. 403.

Habitat. On cotton, *Croton*, *Hibiscus esculentus*, *Hibiscus rosasinensis*, *Thespesia populnea*, *Hygrophila spinosa*, sandalwood (Coimbatore) ; also on nutmeg shoots, Courtallum (Tinnevelly). The shape of the scale is somewhat oval and very convex in form ; the colour varies from deep chocolate brown to bluish black.

Known as the "black bug" and recorded on various other plants including coffee, rubber, etc., sometimes this assumes the role of a nasty pest. It has a world-wide distribution. On the Portia tree (*Thespesia*) I have found it doing serious damage.

Recently in a bad attack of this pest on cotton in Coimbatore, I noted a small Chalcidid wasp—very similar in appearance to *Scutellista cyanea*, Mots.—acting as a very effective natural check on this scale.

70. *Lecanium hemisphæricum*, Targ.

Lecanium hemisphæricua, Targioni Tozzetti, Studi sulle. Cocciniglie, 1867, p. 27.

Lecanium coffeæ, Cotes, I. M. N., I, 1889, p. 117.
Lecanium hemisphæricum, Green, C. of C., 1896, p. 232, pl. LXXXV ; Fletcher, South Ind. Ins., p. 514, f. 402.
Saissetia hemisphærica, Cockerell, The Ent. Student, II, 1901, p. 32.

This well-known insect is known as the " brown bug of coffee " in South India.

Habitat. It has been noted on coffee, ferns, tea, guava, *Tabernæmontana*, etc. The scale is very convex and spherical in shape and has a chocolate brown colour. It is a serious pest of coffee in the planting districts of South India and is often found in company with the " green bug " *Lecanium viride*. There is a good deal on record regarding the pests of coffee in the second reference noted above. Numerous hymenopterous parasites have been noted on this insect.

71. *Lecanium hemisphæricum*, var. *filicum*, Bdv.

Lecanium filicum, Signoret, Ann. Soc. Ent., Fr., 1873, p. 436.
Lecanium hemisphæricum, var. *filicum*, Green, Ent. Mon. Mag., 1897, pp. 70—77.

Habitat. On garden ferns, Shevaroys and Ganjam. This is popularly known as the " Fern scale " and is generally carried from place to place in cultivated ferns. Some coccidologists make this a separate species. General form more or less like *hemisphæricum*, but different from it in having some carinæ on the surface. Colour shining reddish-brown.

72. *Lecanium hesperidum*, L.

Coccus hesperidum, Linn, Syst. Nat. (ed. X) 1758, I. p. 455.
Lecanium hesperidum, Burmeister, Hand. Ent., II, 1835, p. 69.
Lecanium hesperidum, Green, C. of C., I, 1899, p. 188, pl. LXII.
Lecanium hesperidum, Newstead, Mon Br. Cocc., II, 1902, p. 78, pl. L.

Habitat. On coconut leaf, Madilagam, South Malabar, and on *Citrus* shoots, Mandapetta, Godavari.

The scales are pale yellowish-brown in colour, and a number of them are found together in patches on the coconut leaves visited by ants. Green doubts whether the material on coconut is *hesperidum*. He says " not typical ; the antennæ show a tendency to become 8-jointed and the dermal cells are obscure." Noted by Green in Ceylon on *Amaranthus*, *Bignonia*, etc. This is known as the " soft scale " and has a

world-wide distribution. Professor Newstead who discovered the winged male has very recently described it on p. 360, *Bull. Ent. Res.*, VII, 1917. Very recently I have collected this insect on red-gram stem also in Godavari. No previous record from India.

73. *Lecanium oleæ*, Bernard. (Pl. IX, fig. 26.)

Lecanium oleæ, Walker, Cat. Br. Mus. Hom., 1852, p. 1070.
Lecanium oleæ, Green, C. of C., 1899, p. 227, pl. LXXXIII.
Saissetia oleæ, Cockerell, Ent. Student, II, 1901, p. 31.
Lecanium oleæ, Newstead, Mon. Br. Cocc., II, 1902, p. 126, pl. LVII.; Fletcher, South Ind. Ins., p. 515, f. 404.

Habitat. On tamarind fruits and stalks, *Erythrina* leaves and shoots, and stem of *Hygrophila spinosa* (Coimbatore); on coffee (Coorg), on *Sesbania—Agathi*—(Bellary), and on *Thespesia* in different places. This is the common olive scale of European countries. The scale is chitinous and hard and has a very convex form with angular prominences; the body of a mature adult has two lateral and one transverse carinæ forming the shape of an H; the colour dull purplish brown. Immature ones have a yellowish brown tinge. It has been noted on a variety of plants in Ceylon.

74. *Lecanium longulum*, Douglas.

Lecanium longulum, Douglas, Ent. Mon. Mag., 1887, p. 97.
Lecanium longulum, Green, I. M. N., IV, 1896, p. 8.
Lecanium longulum, Green, C. of C., p. 221, pl. LXX.
Lecanium longulum, Newstead, Mon. Br. Cocc., II, 1902, p. 86, pl. L.

Habitat. On red-gram stem, Mandapetta, Godavari District; both adult and the orange-coloured larvæ found together. The smooth yellowish brown females are much longer than broad. The species resembles *Lecanium hesperidum* to some extent, the young may be mistaken for the latter; but the number of antennal joints in the latter are seven and in *longulum* eight. Noted by Green on *Acacia*, *Albizzia*, *Loranthus*, etc., in Ceylon, and by others on *Citrus* in America. No previous record from India.

75. *Lecanium* (*Paralecanium*) *expansum*, Green.

Lecanium expansum, Green, I. M. N. IV, 1, 1896, p 9.
Lecanium (*Paralecanium*) *expansum*, Green, C. of C., 1899, p. 235, pl. LXXXVI.

Fig. 27. *Lecanium ramakrishnæ*, Green M.S., on *Ficus* shoots.

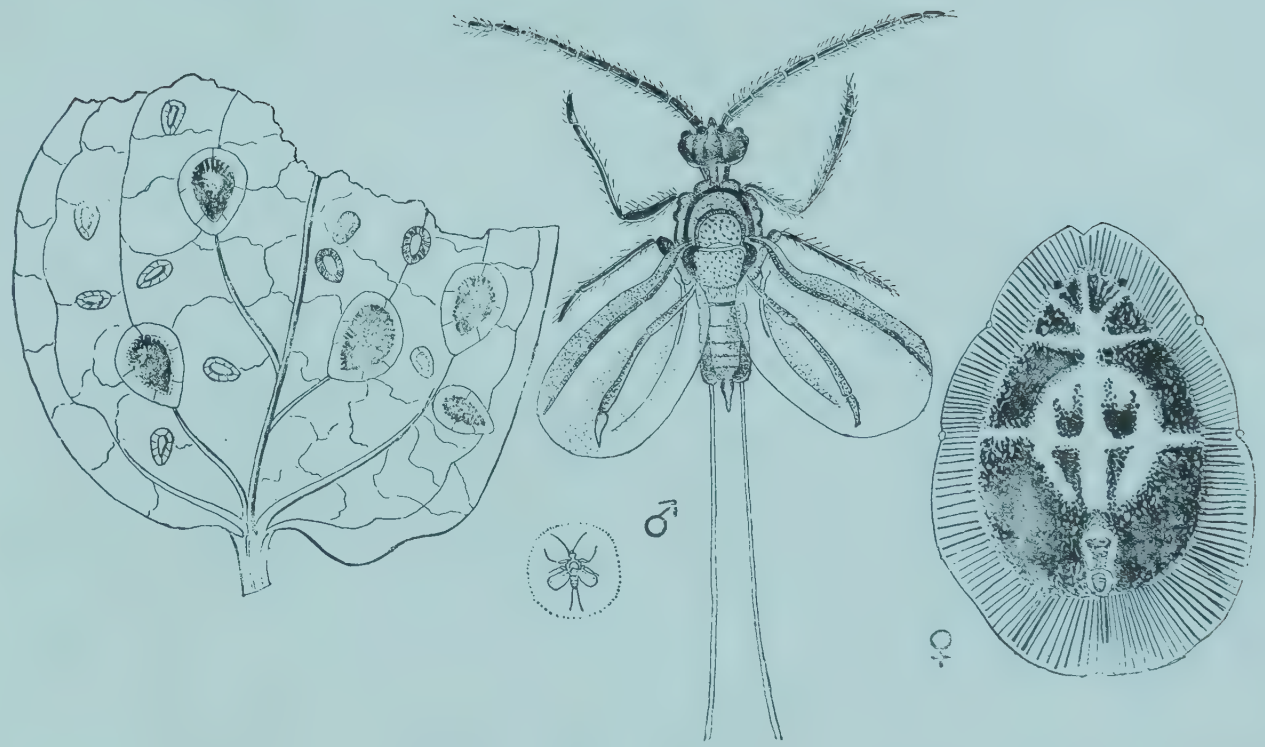


Fig. 28. *Lecanium marsupiale*, Green.

On the left is a portion of leaf of black pepper with male and female scales, natural size; in the centre is winged male, and on the right an adult female, magnified. (After Green.)

(From *South Indian Insects*, fig. 405.)

PLATE X.

Lecanium expansum, Green, Mem. Dept. Agri., India, Ent. Ser., II, 1908, p. 29.

Habitat. On *Calophyllum*, Madras and S. Arcot. Sometimes bad on this plant. Recorded before on *Ficus retusa* from Mysore.

76. *Lecanium formicarii*, Green.

Lecanium formicarii, Green, I. M. N., IV, I, 1896, p. 10.
Lecanium formicarii, Green, C. of C., 1896, p. 190, pl. LXIV.
Lecanium fromicarii, Green, Mem. Dept. Agri., India, Ent. Ser., II, 1908, p. 29.

Habitat. On undetermined plant, Mysore (Lefroy coll.). I have not seen this interesting form which is said to be found enclosed in nests of ants—especially the ant *Cremastogaster dohrni*. Noted by Green on tea, cinchona, *Macaranga*, etc., in Ceylon.

77. *Lecanium ramakrishnæ*, Green MS. (Pl. X, fig. 27.)

Habitat. On distal shoots of *Ficus bengalensis*, Kothapetta (Godavari District). The adult scales have a bluish-black colour, and in shape the scale is more or less conical. The young insects are of a pale yellowish brown colour and found in company with the adults.

78. *Lecanium signiferum*, Green.

Lecanium signiferum, Green, C. of C., 1899, p. 197, pl. LXVIII.

Habitat. On plantain leaf, Golgonda (Vizagapatam District). The scale is yellowish green in colour. On the dorsal surface a reddish brown mark in the form of a long stripe with two cross bars is prominent. No previous record from India.

79. *Lecanium adersi*, Newstead.

(Newstead, Bull. Ent. Res., VII, 1917, p. 357.)

Habitat. On mango (Coimbatore). The females are very flat, irregularly oval and chocolate-brown in colour; the male puparia are smaller and glassy white in appearance. Both male and female puparia are found in numbers on the inner surface of the leaves; the females are chiefly found along the midribs. No previous record from India. Professor Newstead has only recently described the form, for the first time, from specimens collected on mango in Zanzibar in the above reference. I have very recently discovered the winged male from specimens on mango

80. *Lecanium tessellatum*, Sign.

Lecanium tessellatum, Signoret, Ann. Soc. Ent., Fr., 1873, p. 401.
Lecanium tessellatum, Green, I. M. N., IV, 1, 1896, p. 9.
Eucalymnatus tessellatum, Cockerell, A. M. N. H., IX 1902, p. 453.

Habitat. On *Calophyllum* leaves (Coimbatore). The flattened oval reddish-brown scales are easily made out on the leaves though they are not found together in numbers but only isolated. Noted elsewhere on palms, *Sapindus*, ferns, etc. No previous record from India.

81. *Lecanium mercaræ*, Green MS.

Habitat. On coffee, Mercara, Coorg (Fletcher coll.). Mr. Green who kindly identified the species is expected to describe it elsewhere.

82. *Lecanium gymnospori*, Green.

Lecanium gymnospori, Green, Mem. Dept. Agri., India, Ent. Ser., II, 1908, p. 29.
Coccus gymnospori, Sanders, U. S. A. Bull., Tech. Series, No. 16, Pt. III, 1909, p. 45.

Habitat. On *Gymnosporia*, Narasaraopet, Guntur District. First described by Green from specimens collected by Lefroy. No locality given.

83. *Lecanium marsupiale*, Green. (Pl. X, fig. 28.)

Lecanium marsupiale, Green, Mem. Dept. Agri., India, Ent. Ser., II, 1908, p. 30.
Lecanium marsupiale, Green, C. of C., Pt. III, 1899, p. 212, pl. LXXV ; Fletcher, South Ind. Ins., p. 516, f. 405.

Habitat. On pepper leaves (South Wynaad, Malabar and Anamalais). The flat shining reddish-brown scale is comparatively larger in size than many species. Green notes it on *Anona* and *Pothos scandens* in Ceylon. The deep pouch on each side of the under surface of the abdomen is quite characteristic ; the young are found in these pockets.

84. *Lecanium depressum*, Targ.

Lecanium depressum, Targioni Tozzetti, Coccidæ, 1869 p. 29.
Lecanium depressum, Singnoret, Ann. Soc. Ent., Fr., 1873, p. 439.

Fig. 29. *Lecanium acutissimum* Green.

(1) Scales on coconut leaf; (2) a magnified scale.

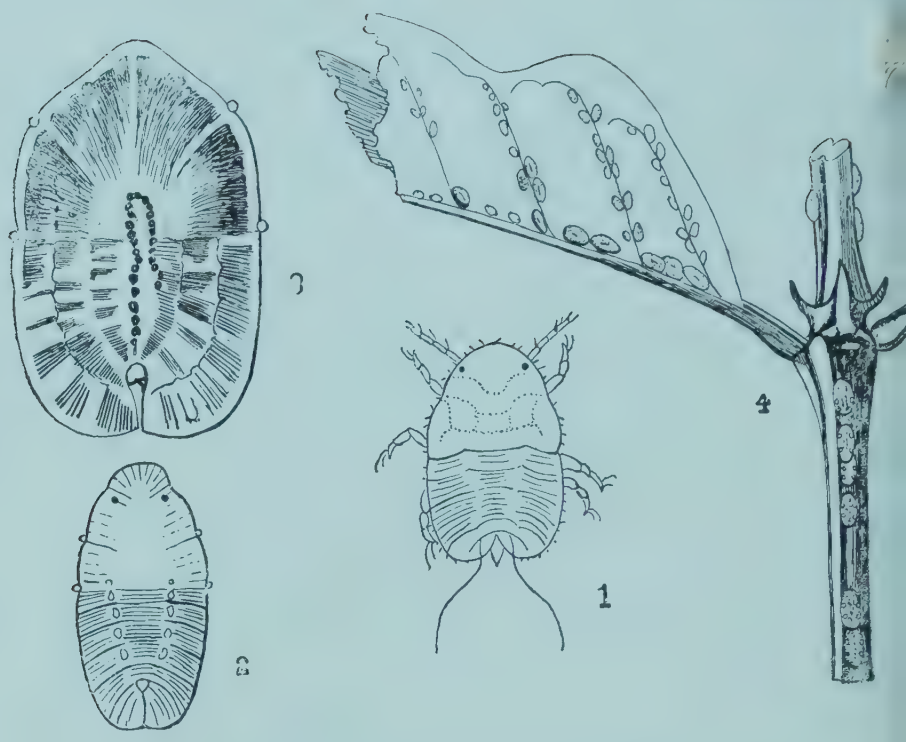


Fig. 30. *Lecanium viride*, Green.

(1) Young nymph from above, greatly magnified; (2) Female of second st magnified; (3) Adult female, from above, ×15; (4) Scales *in situ* branch of coffee, natural size. (After Green.)

(From *South Indian Insects*, fig. 401.)

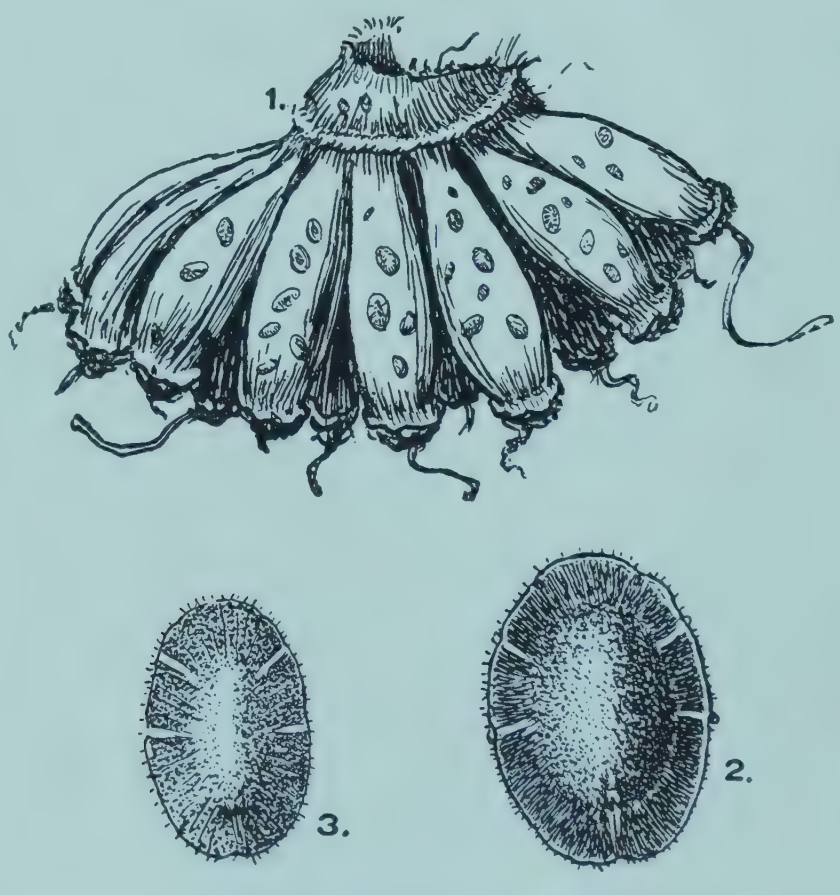


Fig. 31. *Lecanium discrepans*, Green.

(1) Scales on plantain fruits; (2) and (3) Scales in different stages of growth.

Habitat. On *Eranthymum*, *Thespesia populnea* and plantain leaf (Coimbatore). No previous record from India. Maskell considers this synonymous with *Lecanium nigrum*, N. (vide *Entomologist*, 1894).

85. *Lecanium acutissimum*, Green. (Pl. XI, fig. 29.)

Lecanium acutissimum, Green, I. M. N., IV, 1, 1896, p. 10.
Lecanium acutissimum, Green, C. of C., 1899, p. 218, pl. LXXVIII.

Habitat. On coconut leaf, Coimbatore. Few isolated ones only. I also found a specimen on mango leaf recently.

The scales are long and very narrow and pointed at both ends. In colour the scale is deep reddish brown to black. Green records it on coconut, Areca, *Piper*, mango, etc., in Ceylon. No previous record from India.

86. *Lecanium viride*, Green. (Pl. XI, fig. 30.)

Lecanium viride, Green, Ent. Mon. Mag., XXV, 1899, p. 248.
Lecanium viride, Cotes, I. M. N., 1889, pp. 49—117 (a long account).
Lecanium viride, Cotes, I. M. N., II, 1893, p. 166.
Lecanium viride, Cotes, I. M. N., III (*b*), 1894, p. 18.
Lecanium viride, Green, C. of C., 1899, p. 199, pl. LXIX; Fletcher, South Ind. Ins., p. 513, fig. 401.

The adult insect is bright pale green with an irregular loop of dark spots seen through the dorsal surface of the body which can be clearly noted. By this structure it can be easily distinguished from allied forms. This is the notorious "green bug" of coffee commonly found in the planting districts of South India and one of the very few well-known scale insects of this region. Considerable damage by this pest to coffee is now and then reported from the Shevaroys and the Nilgiris. It has recently appeared in Coorg and Mysore also. In 1899, Mr. E. E. Green wrote from Ceylon that "the green scale has practically wiped out coffee cultivation in many districts." A good account is given of this pest in the pages of *Indian Museum Notes* quoted above.

Habitat. Besides coffee it has been noted on *Citrus* trees (Bangalore and Nilgiris), *Aegle* and *Carissa* (Coimbatore), and tea, guava, *Citrus*, *Plumiera acutifolia*, etc., on the Nilgiris. Some Chalcidid parasites are also found. Very often found in company with *Lecanium hemisphæricum*. Some predacious Coccinellids have also been noted on this pest, but it is doubtful whether any of these play any effective part as natural enemies.

87 *Lecanium* (*Coccus*) *colemani*, Kann.*

(Bull. No. 4, Ent. Series, Mysore Agr. Dept., p. 14, 1918.)

Habitat. On coffee, Mysore. I have not seen this species. It is very closely allied to *L. viride*, Green, though some structural differences are said to be present between the two. It is probably only a local race of the "green scale".

88. *Lecanium ophiorrhizæ*, Green.

Habitat. On *Diospyros chloroxylon*, Kurnul (Isaac coll.).

Noted before from Ceylon; new to India.

89. *Lecanium discrepans*, Green. (Pl. XI, fig. 31.)

Lecanium discrepans, Green, C. of C., Pt. III, 1904, p. 204, pl. LXXX.

Habitat. On mango leaf, Palacole, Godavari District. Very closely allied to *L. formicarii*. Gr. Green records this insect on tea and in nests of the ant *Cremastogaster dohrni*. Not recorded from India till now.

Lecanium, sp.

A species of *Lecanium* on *Agave* leaf-sheath, Cuddappah, sent to Mr. Green; is reported to be possibly new, but the specimens were found imperfect.

HEMILECANIUM, Newstead.

90. *Hemilecanium imbricans*, Green. (Pl. XII.)

Lecanium imbricans, Green, I.M.N., V, 3, 1903, p. 94.

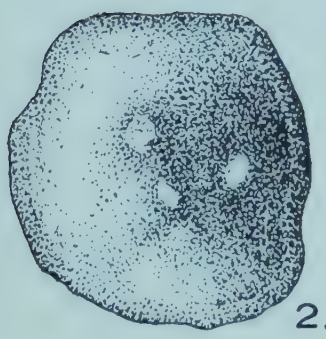
Hemilecanium theobromæ, Newstead, Journ. Ec. Biol., III, 1908, p. 39 [good figures].

Hemilecanium imbricans, Green, Journ. Ec. Biol., V, 1910, p.6; Fletcher, South Ind. Ins., pp. 516-517, fig. 406.

Habitat. On stem of *Jatropha multifida*, a common garden plant (Coimbatore).

The scale is large, about half an inch in diameter, and one of the largest of scales. Colonies of these are found on the main stem and shoots of the host-plant, the whole mass giving a glittering white appearance. The external structure of the scale is quite protective and whole mass of these scales will be easily mistaken for the bark of the plant. "The insect imitates little bosses or excrescences on the bark of the plant stem and so deceptively in shape and colouring that it requires some experience before you recognize the animals as such." Originally described by Green from specimens collected on *Ficus mysorensis* by Dr.

*Mr. Green (p. 149 of T. E. S., 1918) says:—"It seems questionable if there is sufficient justification for the erection of *this* new species".



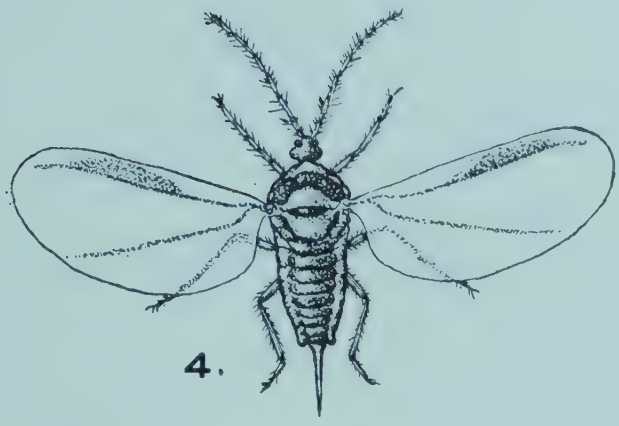


Fig. 32. *Hemilecanium imbricans*, Green.

(1) Young and old scales on *Jatropha* stem; (2) Female scale, dorsal view; (3) Female scale, ventral view; (4) Adult winged male; (5) Male puparium, dorsal view; (6) Male puparium, ventral view; (7) Antenna of male; (8) Leg of male.

Watt. Noted on *Ficus*, spp. and red cedar in Mysore and the Shevaroys. Found as a pest of cacao in Africa, hence the specific name given by Newstead. I recently noted this on *Ailanthus excelsa*. A sooty black blight on the main stem and branches of a tree attracted my attention and the same was found to be the result of an attack by this insect. I have discovered the winged male which has not been noted till now. The male is 3 mm. long and of a pinkish colour covered with a mealy white bloom. The costal nervure of the wing is deep purple. No caudal filaments present.

DACTYLOPIINÆ.

This subfamily includes those Coccidæ which are popularly known as "mealy-bugs".

DACTYLOPIUS, Costa.

91. *Dactylopius indicus*, Green.

Coccus indicus, Green, Mem. Dept. Agri., India, Ent. Ser., II, 1908, p. 28.

Coccus cacti, var. *ceylonicus*, Green, I.M.N., IV, 1, p. 212, 1896, p. 7.

See also I. M. N., IV, 4, for Maskell's remarks on this species.

Habitat. On *Opuntia*, Mandapetta, Godavari District, December. This is the well-known wild cochineal insect famous for its beautiful dye. It was found in abundance in December on prickly pear. The soft mealy-covered females are found crowded at the roots of fresh buds and thorns. The colou · of the female is purple brown but is densely covered over by white mealy matter. The tiny delicate two-winged male is seen crawling over these colonies. The body and the limbs of the male are purple-red with a bloom of mealy matter. The wings are snow white. The two posterior processes long and curved at the tip. The puparia of the male are all found in patches resembling the white cocoons of minute parasitic wasps snowy white in colour and cylindrical in shape. Not found on *Opuntia* sp. in the Southern districts.

PSEUDOCOCCUS, Westwood.

(*Dactylopius* of authors.)

92. *Pseudococcus citri*, Risso.

Dorthesia citri, Risso, Essay on Natural His. of Oranges, 1813.
Dactylopius citri, Signoret, Ann. Soc. Ent., Fr., 1875, p. 312.
Dactylopius citri, Green, Mem. Dept. Agri., India, Ent. Ser., II, 1908, p. 22.

Dactylopius citri, Newstead, Mon. Br. Cocc., II, 1902, p. 164.
Dactylopius ci'ri, Lefroy, Mem. Dept. Agri., India, Ent. Ser., II, 1908, p. 122 ; Fletcher, South Ind. Ins., pp. 508-509, fig. 396.
Pseudococcus citri, Clausen, Calif. Agri. Expt. Stn. Bul'. No. 258 1915, p. 21.

Habitat. Found on cacao pods in the Government Gardens, Kallar, Nilgiris, in midsummer. Some of the pods were found badly infested with this mealy-bug and visited by ants in numbers . The adult bug is roughly oval and covered with white powdery wax and having numerous short waxy processes along the margin.

Noted before on coffee in Mysore, and on coffee seedlings and on roots of *Erythrina* and *Ageratum* in Coorg. The insect has a world-wide distribution and is known to be very destructive to *Citrus* and other trees in Europe and America. About forty-five different plants have been noted to be the hosts of this mealy-bug in the different parts of the world.

93. *Pseudococcus longispinus*, Targ. (Pl. XIII, fig. 33.)

Dactylopius adonidum, Signoret, Ann. Soc. Ent., Fr., 1875, p. 306.
Dactylopius adonidum, Cotes, I.M.N., II, 6, 1893, p. 169.
Dactylopius longifilis, Barlow, I.M.N., IV, 1897, p. 75 (insect described).
Dactylopius longispinus, Newstead, Mon. Br. Cocc., II, 1903, p. 167, pl. LXIV.
Pseudococcus longispinus (new name), Newstead, Mon. Br. Cocc., II, p. 255, 1903.
Pseudococcus longispinus, Clausen, Calif. Agri. Expt. Stn. Bull. No. 258, 1915, p. 35.

Habitat. On coconut leaves (Vadanapalle, South Malabar). Bad on young trees, covering the tender unopened fronds in masses. Ants visit them in numbers. Green says the specimens are not typical of the species.

The body of the adult bug is fringed with white waxy marginal processes ; some of the caudal processes are pretty long and often longer than the body. This is known as " the long-tailed mealy-bug." Has been noted before on coffee and cedar in Mysore and on *Croton* in Calcutta. The host plants of this insect number over thirty.

94. *Pseudococcus virgatus*, Ckll. (Pl. XIII, fig. 34.)

Dactylopius virgatus, Cockerell, The Entomologist, 1893, p. 178.
Dactylopius ceriferus, Newstead, I.M.N., III, 5, 1895, p. 24.
Dactylopius talini, Green, I.M.N., IV, 1, 1896, p. 7.

Fig. 33. *Pseudococcus longispinus*, Targ.
(After Essig.)

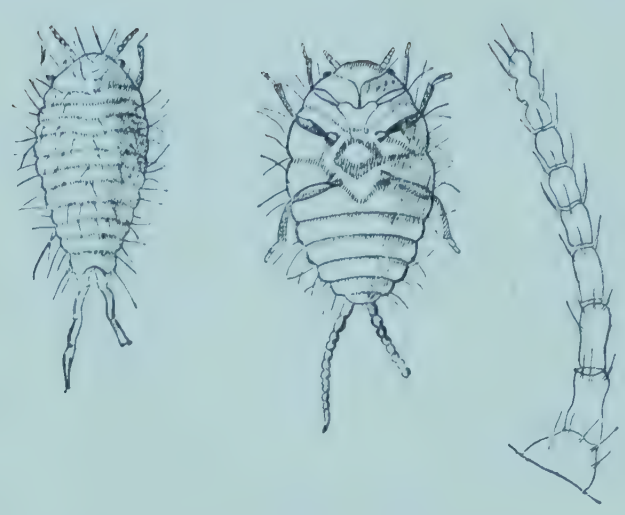


Fig. 34. *Pseudococcus virgatus*, Ckll.
Dorsal and ventral views of insect (enlarged) and antenna (more highly magnified). (After Newstead.)
(From *South Indian Insects*, fig. 398.)

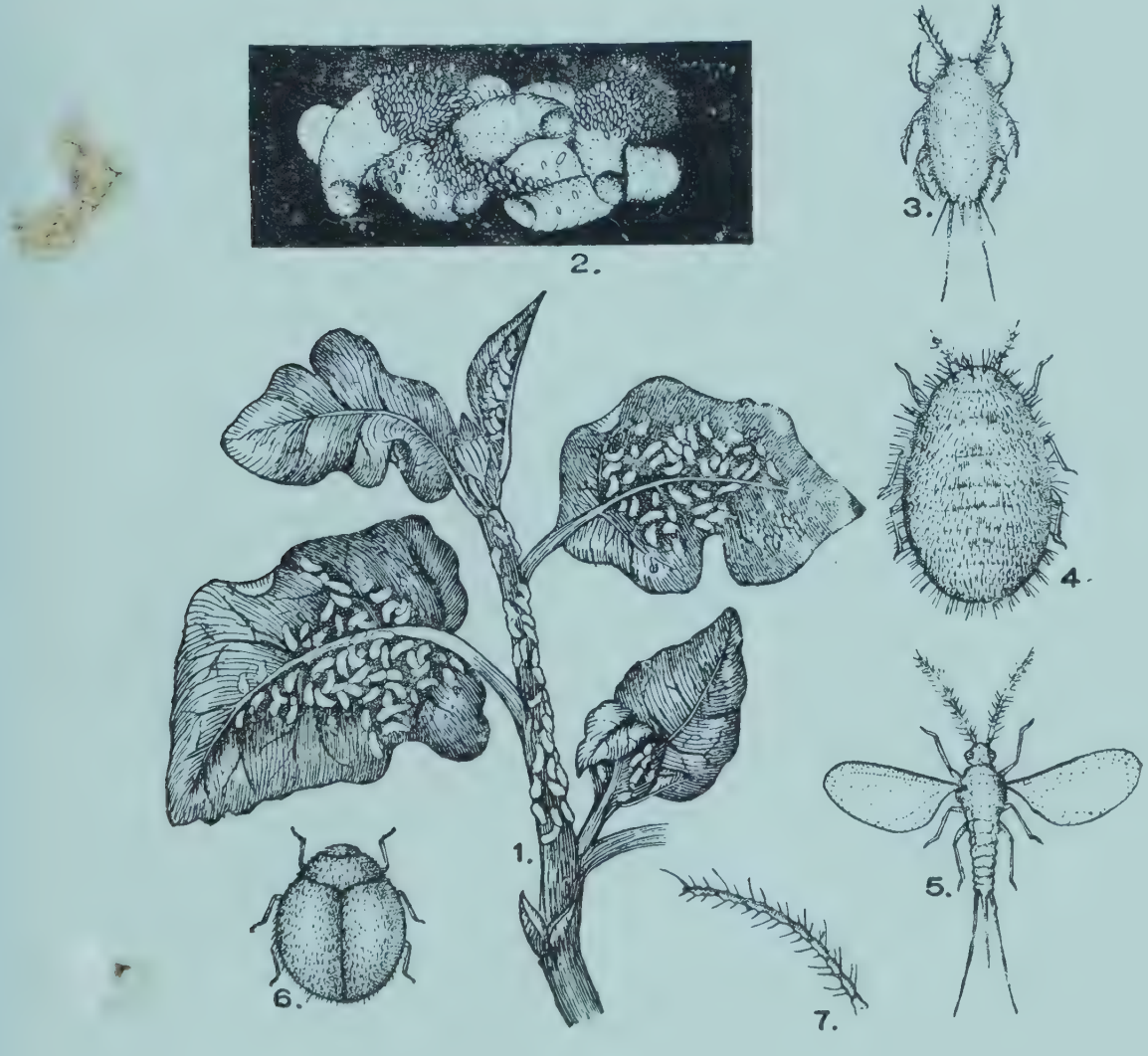


Fig. 35. *Phenacoccus insolitus*, Green.
(1) Brinjal shoot showing infestation; (2) Ovisacs showing young larvæ emerging; (3) and (4) young and older insects; (5) Adult male; (6) Coccinellid predaceous on the insect; (7) Antenna of male.

Pseudococcus virgatus, Kirkaldy, Faun. Haw., III, pt. II, 1902, p. 103.

Habitat. Noted on *Crotons*, tomato and some other plants (Coimbatore). On Cambodia cotton ; Palur, South Arcot (March).

It was noted before in Madras in 1892 by Miss Tomlin. This is a fairly common insect often assuming pest proportions ; the mealy masses of the colonies are often found killing tender plants outright.

95. *Pseudococcus sacchari*, Ckll.

Dactylopius sacchari, Cockerell, Proc. Ac. Nat. Sc. Phil., 1899, p. 266.

Dactylopius sacchari, Green, I.M.N., V, 3, 1903, p. 102.

Pseudococcus sacchari, Newstead, Bull. Ent. Res., VIII, 1917, p. 126.

Habitat. Inside the leaf-sheaths of growing paddy plants The insect often assumes pest conditions. The disease caused to paddy is called " *Soorai* " or " *Chenchoorai* " in the Tamil districts. In badly infested fields the indication of the pest attack is the presence of isolated patches of plants showing stunted growth and gradual fading. Professor Newstead describes the distinguishing features of the adult female in the latest reference noted above.

Found in parts of Coimbatore, Trichinopoly, Tanjore and South Arcot. A rather serious pest occasionally.

96. *Pseudococcus corymbatus*, Green MS.

Habitat. The insect is found in masses covering tender shoots and fruits of jak in Malabar. The colony is visited by the red ant *Œcophylla smaragdina*. Noted on *Citrus* shoots and fruits ; Palacole, Godavari District. It has also been noted to infest shoots of the cotton plant in Coimbatore. The insect is found in thick masses of mealy stuff. In some cases the bolls and shoots of cotton are completely covered up by this sticky white mass. No description of this species has yet been published, but Mr. Green is describing it in his forthcoming volume on the Ceylon Coccidæ.

97. *Pseudococcus crotonis*, Green (nom nud).

Dactylopius crotonis, Green, Tropical Agriculturist, XXIV, 8, 1905, p. 44.

Dactylopius crotonis, Green, Journ. Ec. Biol., 1915, p. 69.

Habitat. On *Adenophyllum* shoots and pomegranate fruit stalk, Coimbatore. On stem and crevices in stem of *Ficus indicus*, Alamanda, Vizagapatam District.

Mentioned by Mr. Green in the above reference as attacking Castilloa rubber in Ceylon. A full description of the species has not

appeared yet. Probably will be found in Mr. Green's coming volume. Mr. Green says that the specimens from Vizagapatam are not typical.

98. *Pseudococcus viridis*, Newst.

Dactylopius viridis, Newstead, I.M.N., III, 5, 1894, p. 25.

Habitat. Noted by Miss Tomlin on *Pithecolobium* and *Hygrophila spinosa* in Madras in 1892, and described by Newstead in 1894.

99. *Pseudococcus cocotis*, Mask.

Dactylopius cocotis, Maskell, N.Z. Transactions, XXII, 1889, p. 149.
Dactylopius cocotis, Cotes, I.M.N., II, 1893, p. 169.
Dactylopius cocotis, Cotes, I.M.N., III, 1, 1893, p. 7.
Dactylopius cocotis, Maskell, I.M.N., III, 1, 1893, p. 66.

Habitat. On coconut leaf, Malabar and the Laccadives. First noted in the latter locality in 1891 by Mr. Dumergue.

100. *Pseudococcus nipæ*, Mask.

Dactylopius nipæ, Maskell, N.Z. Trans., 1892, p. 232.
Dactylopius nipæ Green, Mem. Dept. Agri., India, Ent. Ser., II, 1908, p. 23.
Dactylopius nipæ, Lefroy, Mem. Dept. Agri., India, Ent. Ser., II, 1908, p. 124.
Dactylopius nipæ, Fletcher, Some South Indian Insects, 1914, pp. 509-510, fig. 397.

Habitat. On *Casuarina* stem—Coromandel coast (Noted by V. Subramania Ayyar—see page 8, *Imp. For. Bull.* No. 11, 1912). I have not seen the insect myself. It is very likely to be found on potatoes also, as is the case in North India, where it is often bad and destructive to seed potatoes.

PHENACOCCUS, Ckll.

101. *Phenacoccus insolitus*, Green. (Pl. XIII, fig. 35.)

(Mem. Dept. Agri., India, Ent. Ser., II, 1908, p. 26.)
Phenacoccus insolitus, Newstead, Bull. Ent. Res., VII, 1917, p. 127.

Habitat. This is another insect which has been noted as a pest. It attacks the brinja plant all over South India and has been noted specially in the Chingleput and Coimbatore districts. A plant when badly infested presents a white appearance from a distance looking as though lime was splashed over ; its leaves, stem, and all become literally covered up ; on the leaves it is the under surface that is found more infested. The young

larvæ are pale yellowish green in colour. The prompt destruction of attacked plants or spraying with a dilute contact poison will easily check the insect. The first record was from Pusa on *Sida cordifolia*. I have reared out the winged adult male which was not known till now. It is a tiny pink delicate creature with brownish eyes and transparent wings. The limbs and antennæ are well developed. There are four slender waxy filaments attached to the anal end of the body of which two are long and the other two short. A small Chalcidid parasite is found preying on the scale in numbers. The egg-sacs are cream-white and contain over 400 or 500 eggs which have an yellowish-green colour.

102. *Phenacoccus mangiferæ*, Green.

Pseudococcus mangiferæ, Green I.M.N., IV, 1, 1896, p. 7.

Habitat. On mango, Coimbatore; on *Echitis* leaves and shoots, Anakapalle, Vizagapatam District; but these latter do not appear typical according to Mr. Green. This pale yellow mealy-bug is found commonly on mango around Coimbatore. The body is covered with white mealy matter and the margins have stout white processes. No previous record from India

103. *Phenacoccus ballardi*, Newstead.

Habitat. On mango (Coimbatore), and on an undetermined plant n South Kanara. Professor Newstead has recently described this species in detail (*Bull. Ent. Research*, VIII, August 1917, p. 17). The species is very like *P. iceryoides*, Green.

104. *Phenacoccus iceryoides*, Green.

Phenacoccus iceryoides, Green, Mem. Dept. Agri., India, Ent. Ser., II, 1908, p. 26.

Phenacoccus iceryoides, Lefroy, Mem. Dept. Agri., India, Ent. Ser., II, 1908, p 129.

Habitat. On shoots of *Odina wodier* in Coimbatore. On *Citrus* shoots; Palacole, Godavari District. On mango shoots and fruits; Alamanda, Vizagapatam District. Noted a'so on *Boswellia* in Tanjore. On mango in Calcutta and on *Capparis* in Surat. It is pretty bad on mango and *Citrus* n the Northern Circars, and t is found destructive to the young shoots of *Odina wodier* on the Coimbatore farm, the hoots and young leaves being literally 'cove ed with the bug. Recently I noted the Lycaenid butterfly, *Spalgis epius*, West., feeding in numbers on this mealy-bug.

Another spec es of *Ph nacoccus* close to *mangiferæ* was noted on *Thespesia* in Cuddapah. Mr. Green says the material was too fragmentary for exact determination.

105. *Phenacoccus ornatus*, Green MS.

Habitat. On a wild creeper ; Courtallum, Tinnevelly.

Green says he has noted this on a species of jasmine creeper in Ceylon. It is a very delicate and pretty insect.

106. *Phenacoccus quarternus*, Green.

Habitat. On stem of *Casuarina* tree in the galleries of the borer *Arbela*. Coromandel Coast. See page 8 of V. S. Iyer's Bulletin on *Casuarina* pests. (*Imp. For. Bull.* 11 of 1912.)

RIPERSIA, Sign.

107. *Ripersia sacchari*, Green. (Fig. 36.)

(I.M.N., V, 2, 1900, p. 37.)

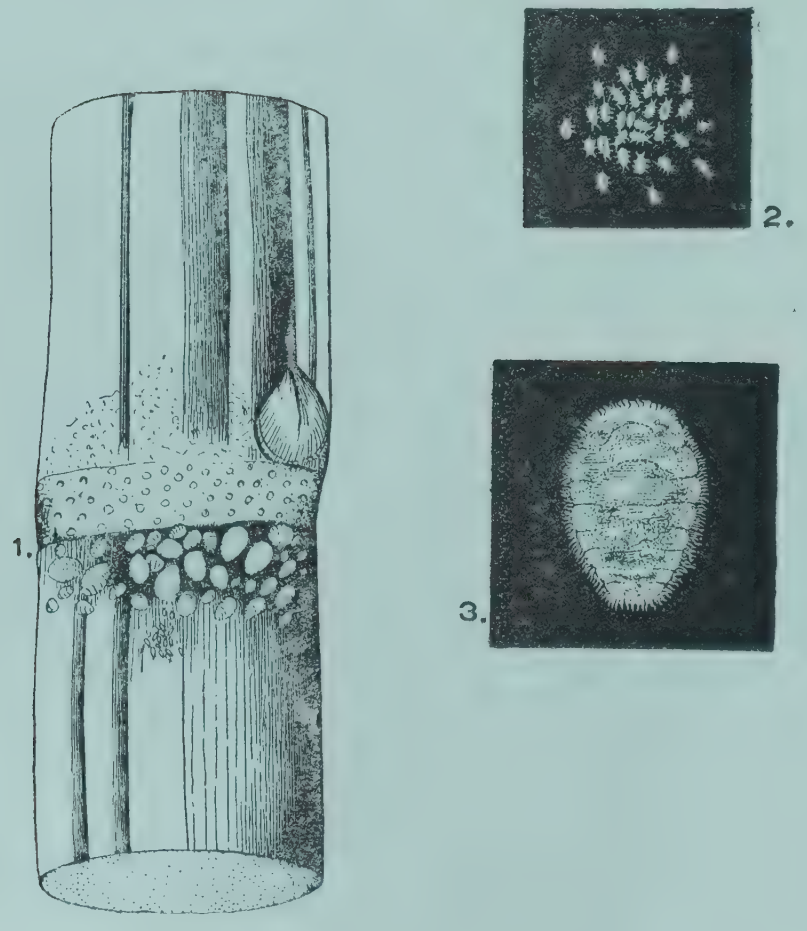
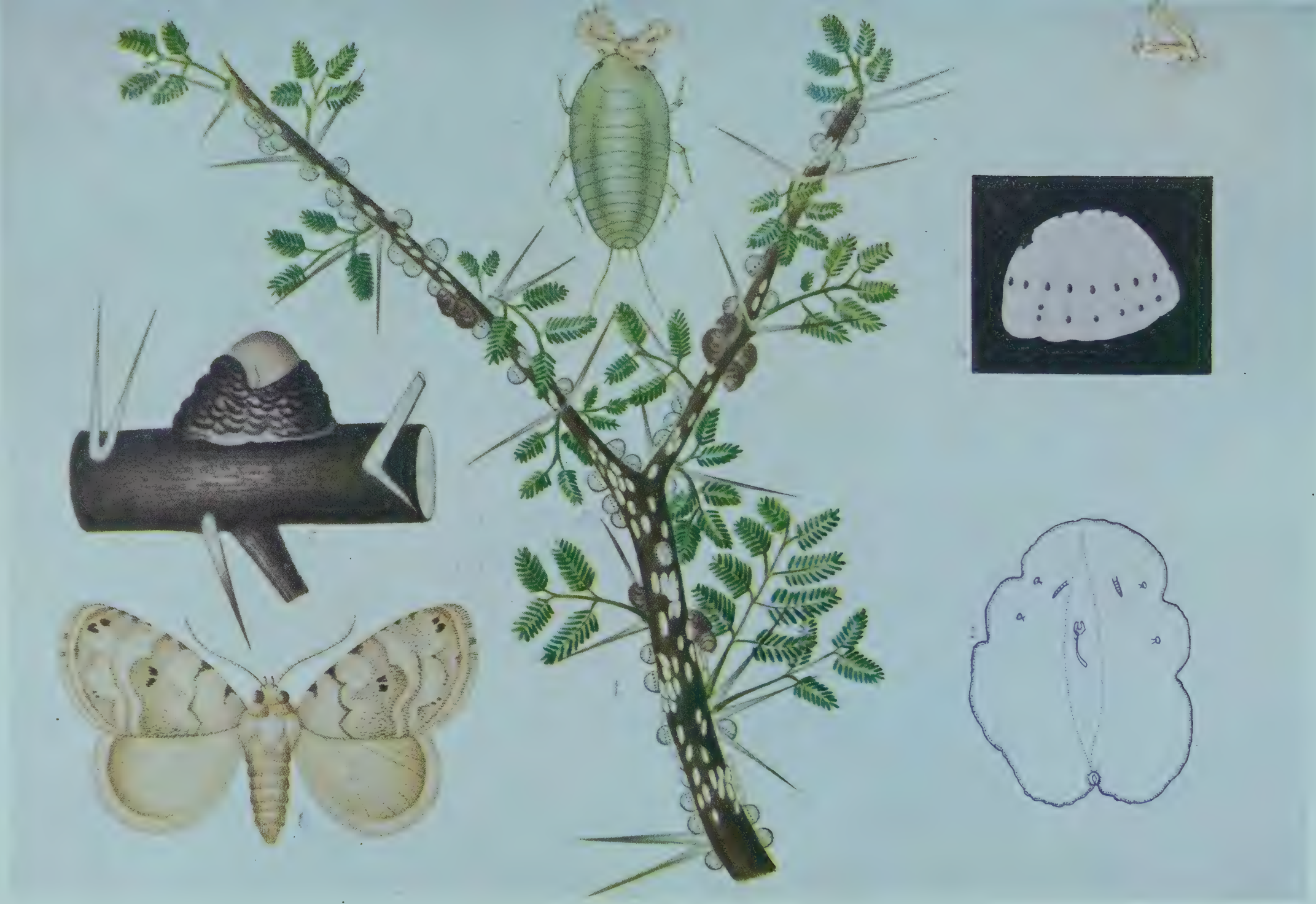


Fig. 36. *Ripersia sacchari*, Green.
(1) Scales on sugarcane (covering sheath of cane removed) ;
(2) Young larvæ ; (3) later stage of larva.

EXPLANATION OF PLATE XIV.

Anomalococcus indicus, Green M.S.

1. Scale infested *Acacia* branch.
2. Adult female scale from nature, × 8.
3. Do. do. mounted, × 14.
4. Young larva, × 44.
5. Cocoon of predatory moth on *Acacia* stem, × 3.
6. Predaceous moth, × 6.



ANOMALOCOCCUS INDICUS, GREEN.

Habitat. On sugarcane, Coimbatore. Sometimes this insect becomes serious and then the sheathing leaves at the lower regions of the cane show colonies of these pinkish white bugs. They anchor themselves chiefly at the nodes of the cane.

Green (*Mem. Dept. Agri., India, Ent. Ser.*, II, 1908, p. 25) speaks of some specimens got on rice plant in Benga' as more or less identical with this species. In the same publicaion (p. 128) Lefroy gives some details of the occurrence of this insect on paddy. I have my own doubt as to whether this is *Ripersia*.

Originally described by Green from specimens on cane collected at Gorakhpur in the United Provinces in 1900.

ANTONINA, Sign.

108. *Antonina maritima*, Green.

Habitat. On underground roots of grass (*Cynodon* sp.), Coimbatore. The insects are found attached to the underground roots of grass. The adult has a pale brown colour but this is fringed over with whitish mealy material. This is a species allied to "the nut grass coccid" (*Antonina australis*, Gr. recorded from Australia on *Cyperus rotundatus* in 1904.)

The Board of Revenue, Madras, suggested the introduction of this foreign insect into India in 1904 to eradicate the grass.

No previous record from India.

ASTEROLECANIINÆ.

ANOMALOCOCCUS, Green.

109. *Anomalococcus indicus*, Green MS. (Pl. XIV.)

Habitat. A scale very commonly found infesting the *babul* tree (*Acacia arabica*) on the Coimbatore College Farm. Sometimes it does considerable damage to young trees which become completely covered up with these white scales. The common black ant, *Camponotus compressus*, is found visiting the scales in numbers and colonies of this ant are found in nests at the foot of the infested tree. A species of Noctuid moth, *Eublemma*, is also found predacious on this scale.

CEROCOCCUS, Comstock.

110. *Cerococcus hibisci*, Green.

Cerococcus hibisci, Green, Ent. Mem., Dept. Agri. Ind., II, 19—21, t. 2, ff 2-4 (1908); Lefroy, *l. c.*, p. 122; Fletcher, South Ind. Ins., p. 508, f. 395.

Habitat. On cotton and *Hibiscus rosa-sinensis*, Coimbatore, Godavari and Madura.

This is popularly known as the "yellow scale of cotton" as the scales have a pale yellowish colour. It is not found however as an important pest of cotton.

111. *Cerococcus bryoides*, Mask.

Planchonia bryoides, Maskell, New Zeal. Trans., XXVI, 1893, p. 84.

Asterolecanium bryoides, Cockerell, Check List, 1896, p. 328.

Habitat. On *Hibiscus rosa-sinensis*, Madras.

ERIOCOCCUS, Targ.

112. *Eriococcus araucariæ*, Mask.

Eriococcus araucariæ, Maskell., New Zeal. Trans., XI, p. 218, 1878.

Eriococcus araucariæ, Green, Ind. Mus. Notes, IV, p. 7, 1896.

Habitat. On a Conifer; Lalbagh Gardens, Bangalore. In Ceylon, Green has found this bad on *Araucaria*. It was pretty bad also on the tree I noted in Bangalore.

113. *Eriococcus lagerstroemiæ*, Kuw.

Bull. Agr. Exp. Stn., Japan, I, 2, p. 182, 1907. (Fig.).

Habitat. On a species of *Dalbergia*, Courtallum, Tinnevelly.

ASTEROLECANIUM, Targ.

114 *Asterolecanium miliaris*, var. *longum*, Green.

Planchonia miliaris, Green, I. M.N. IV, 1, 1896 p. 5.

Asterolecanium miliaris, var. *longum*, Green, C. of C., 1909, p. 339, pl. CXXIX.

Habitat. On bamboo leaf, Coimbatore.

The narrow elongate scales become visible on the foliage only when carefully observed; the colour is like that of the bamboo leaf. Found on both sides of the leaf. No previous record from India.

TACHARDIANÆ.

TACHARDIA, Blanchard.

115. *Tachardia lacca*, Ker. (Pl. XV.)

Carteria lacca, Sign., Ann. Soc. Ent., Fr. 1874, p. 102.

Tachardia lacca, Green, C of C., 1896, p. 3.

Tachardia lacca, Imms and Chatterjee, Ind. Forest Mem., 1915,

EXPLANATION OF PLATE XV.

Tachardia lacca, Kerr.

1. Healthy insects on stick.
2. Unhealthy „ „ „
3. Young lac insect, × 40.
4. A female, 4 weeks old, × 35.
5. „ 13 „ × 15.
6. Young lac insects emerging from a female cell, × 4.
7. Male cell, 13 weeks old, × 12.
8. Wingless male, × 12.
9. Winged male. × 40.

TACHARDIA LACCA, KERR.

Habitat. Noted on *Dalbergia lanceolaria* (Walayar forests); on mango (Saidapet) and on *Pongamia glabra* (Coimbatore).

This is the "lac insect" which forms the most important substance in the manufacture of commercial shellac. This insect was bred on *Zizyphus* trees on the Coimbatore farm and one fairly good crop was got. There is a good deal of literature on this useful insect in the *Indian Museum Notes* and in *Indian Forest Memoirs.*

116. *Tachardia lobata*, Green.

Habitat. On *Thespesia populnea*, Madanapalle, Chittoor District. Mr. Green found one specimen of this species with some other material I submitted to him.

MARGARODINÆ.

MARGARODES Guilding.

The Coccids of this genus are what are known as "ground pearls" and are subterranean in habit. There is a good account of this genus by Mr. Green in the *Records of the Indian Museum*, VII, 1912.

117. *Margarodes formicarum*, Guild.

Margarodes formicarum, Guilding, T.E.S., 1828, p. 115.
Margarodes formicarum, Atkinson, J. A. S. B., LV, Pt. 2, No. 3, 1886.

Recorded as having been noted in South India. Mr. Green in his note on the genus *Margarodes* in the *Records of the Indian Museum*, VII, Pt. I, p. 65, 1912, doubts the collection of any species of this genus before *Margarodes indica* in 1910. He says *M. formicarum* is not reliable.

118. *Margarodes indica*, Green.

(Rec. Ind. Mus., VII, Pt. I, No. 5, 1912, p. 73.)

Bangalore and Bombay. Recorded by Green in the *Records of the Indian Museum.* There is no correct record of the exact habitat of this species.

119. *Margarodes niger*, Green.

(Rec. Ind. Mus., VII, Pt. I, 1912, p. 75.)

Habitat. In soil under roots of grass; colour of nymphal cyst opaque dull black. The cysts are liable to be mistaken for seeds of *Canna indica.* Mysore, Bellary and Coimbatore.

120. *Margarodes papillosa*, Green.

(Rec. Ind. Mus., VII, Pt. I, 1912, p. 74.)

Habitat. Bellary. In soil under grass (Ramachandra Rao coll.). Previous records from Bellary near egg-masses of Acridiid grasshoppers and under rose plants, Bangalore.

MONOPHLEBINÆ.

MONOPHLEBUS, Burm.

121. *Monophlebus tamarindus*, Green.

Habitat. On garden *Crotons* ; Samalkota, Godavari District.

122. *Monophlebus leachii*, Westw. (Pl. XVI, fig. 37.)

Monophlebus leachii, Westwood, Arc. Ent., I, 1841, p. 22.
Monophlebus leachii, Atkinson, J. A. S. B., 1886, p. 293.
Drosicha leachii Cockerell, Ent., 1902, p. 283.

Recorded as got from Malabar and Pondicherry by Atkinson.

I have some more material of *Monophlebus*, but the different forms have not yet been specifically determined.

WALKERIANA, Sign.

123. *Walkeriana pertinax*, Newst.

Walkeriana pertinax, Newstead, P. Z. S., 1900, p. 197.
Aspidoproctus? pertinax, Newstead, Bull. Ent. Res., VIII, 1917, p. 125.

Habitat. Noted on a wild plant, Bangalore, June 1908. First described by Newstead from specimens got from Central Africa. No previous record of it from India. I found only one specimen. Professor Newstead finds very little difference in structure between my specimen and the cotypes regarding the larvæ found under the specimen.

124. *Walkeriana polei*, Green.

(I. M. N., IV, 1896, p. 6 ; and Mem. Dept. Agri., India, Ent. Ser., II, 1908, p. 19.)

Habitat. Recorded on an undetermined plant from South India. Originally described by Green from specimens collected on *Dodonæa viscosa* in Ceylon.

Fig. 37. *Monophlebus leachii*, Westw.
Adult male. (From Westwood.)

Fig. 38. *Walkeriana cinerea*, Green, on *Lawsonia* stem.

Fig. 39. *Walkeriana cinerea*, Green.
Female magnified.

Fig. 40. *Orthezia insignis*, Dougl.
(1) Scales on *Lantana*; (2), (3) and (4) insect in different stages.

125. *Walkeriana cinerea*, Green. (Pl. XVI, figs. 38 and 39.)

Walkeriana cinerea, Green, Mem. Dept. Agri., India, Ent. Ser., II, 1908, p. 18.

Walkeriana cinerea, Lefroy, Mem. Dept. Agri., India, Ent. Ser., II, 1908, p. 121.

Habitat. Found in numbers on the stem of *Lawsonia alba* and sandalwood tree (Vadanapalle, South Malabar). On *Lawsonia* the insect was doing serious damage. The whole tree appeared sooty black, due to the mould, following the scale infestation. The colour of the adult insect very closely resembles that of the tree bark. Recently found on *Thespesia* in Coimbatore.

ICERYA, Signoret.

126. *Icerya seychellarum*, Westw.

Dorthesia seychellarum, Westwood, Gard. Chron., 1855, p. 830.

Coccus sacchari, Signoret, Ann. Soc. Ent., Fr., 1869, p. 93.

Icerya seychellarum, Maskell, N. Z. Tans., 1897, p. 329.

Icerya tangalla, Green, I. M. N., IV, 1, 1896, p. 7.

Icerya seychellarum, Green, Mem. Dept. Agri., India, Ent. Ser., II, 1908, p. 18.

Habitat. On *Cassia tora*; Kottur, Bellary District. Several bushes were found almost completely covered by colonies of this beautiful creature. The insect when alive has a beautiful pink and yellowish colour with numerous creamy white processes. Noted on mango in Bombay, and on *Casuarina* trees along the Coromandal Coast

127. *Icerya ægyptiaca*, Dougl.

Crossotosoma ægyptiacum, Douglas, Ent. Mon. Mag., 1890, p. 79.

Icerya ægyptiacum, Ril. and How., Ins. Life., III, 1891 (with figures), p. 97.

Icerya ægyptiaca, Newstead, Mon. B. Cocc., II, 1902, p. 248.

Habitat. On bread-fruit tree (*Artocarpus incisa*); Vadanapalle, South Malabar. On jak (*Artocarpus integrifolia*); Kallar, Nilgiris 1,200 feet. The tender shoots and leaves were found literally covered by this pest in masses of white cottony stuff. Found also on *Ficus* leaves; Simhachalam, Vizagapatam District. Noted also on various garden plants in different places.

128. *Icerya pilosa*, Green.

Icerya pilosa, Green I. M. N., IV, 1, 1896, p. 7.
Icerya pilosa, Green, Mem. Dept. Agr., India, Ent. Ser., II, 1908, p. 18.

On *Spinifex squarrosus*, Madras (collected by Miss Taylor).

ORTHEZIANÆ.

ORTHEZIA, Bosc.

129. *Orthezia insignis*, Dougl. (Pl. XVI, fig. 40.)

Orthezia insignis. Green, Trop. Agri., XXVI, 1895.
Orthezia insignis, B. J., XII, 1899, p. 547.
Orthezia insignis, Sanders, Journ. Ec. Ent., II, 1909, p. 430.
Orthezia insignis, Newstead, Mon. Br. Cocc., II, 1902, p. 236, pl. LXXV.

This is the well-known *Lantana* bug. Though it is fairly common in other countries and even in Ceylon, it has not appeared in South India. However, it was once noted in a plantation on the Nilgiris and I was told the pest was at once destroyed. A few insects from this lot appear to have been taken to Bangalore and were found in Dr. Coleman's office compound on *Lantana*. It would be very beneficial if it confines its ravages to this plant alone; but it is not unlikely that other and useful plants may be infested, if introduced. The adult female insect is easily distinguished by the peculiar arrangement of the white waxy laminæ; the long tubular white ovisac at the anal end is the most striking feature. There are also short white waxy processes at the sides and a double row of similar processes along the back; the insect is olive green in colour and the legs are well developed. It has been noted to breed on more than thirty different host plants in Ceylon. This was recently (March 1919) sent up as damaging some wild plants from a tea estate in S. Wynaad. This is the first official report of this insect from within India.

1918

Cawnpore-American Cotton: An Account of Experiments in its Improvement by Pure Line Selection and of Field Trials, 1913-17,

[*Received for publication on 31st October, 1918.*]

I. Introductory.

IN the *Agricultural Journal of India* for October 1913, a preliminary account was given of the results obtained with the acclimatized American cotton known as "Cawnpore-American", and the conclusion was there reached that this cotton met a distinct demand and could be profitably grown, provided the marketing of the unginned cotton (*kapas*) could be organized. It was also shown that there was probably some margin for improvement in the crop itself both as regards uniformity of the lint and ginning percentage. It is now proposed to give a brief account of the results which have been obtained in the improvement of the crop by pure line selection, and of the further information which has been gathered in the course of the attempts made to establish this crop on a commercial scale.

Dealing first with the field crop Cawnpore-American, in its original form, the statement as regards yield previously made has been fully justified, and the results obtained on the Kalianpur Seed Farm show definitely that, on the average, Cawnpore-American is at least as good a yielder as the highest yielding types of *desi* cotton when both are sown with irrigation at the optimum time.

In 1913, careful comparisons on uniform land were made of the yields obtained from Aligarh white-flowered *desi* cotton and Cawnpore-American, both at Cawnpore and Etawah, with the following results :—

	Cawnpore-American	Aligarh white-flowered
Cawnpore . .	695 lb. *kapas* per acre .	662 lb. *kapas* per acre
Etawah . .	1,187 lb. ,, ,, . .	1,139 lb. ,, ,,

A similar comparison was carried out at Etawah, in 1914 and 1915, with the following results :—

	Cawnpore-American	Aligarh white-flowered
1914 . . .	1,066 lb. *kapas* per acre . .	961 lb. *kapas* per acre
1915 . . .	699 lb. „ „ . .	454 lb. „ „

The above figures are averages only ; detailed figures are given in the farm reports for the years in question.

With such crops as cotton, however, yields obtained from small experimental plots are occasionally misleading, if for no other reason than because it is possible to give such areas practically perfect cultivation. The results obtained from large fields at the Cawnpore (Kalianpur) Seed Farm, from 1913 to 1917, are, therefore, of interest, and these are given below :—

Yields of kapas *in lb. per acre at Kalianpur.*

	Cawnpore-American		Aligarh white-flowered *desi*	
	Area in acres	Yield	Area in acres	Yield
1913	23·0	840	13·0	830
1914	18·9	650	5·6	764
1915	20·5	485	9·8	469
1916	13·8	421	9·5	510
1917	9·15	431	10·4	359
1918	11·0	830	4·0	799

Of these, the only good cotton year was 1913, in which year the average yields of Cawnpore-American and Aligarh white-flowered *desi* were practically identical, but the yields from the best field of American (1,336 lb. per acre) were much higher than those obtained from the *desi* variety (1,053 lb. per acre). The *desi* variety used for comparison is a far higher yielder than the ordinary cotton of the Cawnpore and neighbouring districts, but in respect to quality is the lowest in the province, and its more general introduction would be strongly opposed by most Indian spinners. During the last three years the cotton crop has throughout the province been seriously damaged by excessive

rain, but even so American cotton has yielded on the whole as well as *desi*. As will be seen later, some of the pure lines isolated from the mixed crop are distinctly better yielders than the original crop, and it seems clear that, as regards yield, there is no obstacle to the general introduction of this cotton in the irrigated portion of the Central Circle.

Careful observation of the crop as grown by cultivators, and also detailed observations on our farm crops, bring out certain definite limitations, however, in respect to this cotton, that are of no small importance in its establishment as a commercial crop. It is of primary importance that American cotton should be sown with adequate preliminary irrigation well before the monsoon ; failure in this respect results in stunted plants which never recover their vigour. In the early part of the monsoon Cawnpore-American cotton is undoubtedly somewhat more susceptible to water-logging than *desi* cotton ; on the other hand, farm results and the experience of cultivators go to show that it is less damaged by heavy rain at the end of the monsoon than *desi* cotton. These differences are undoubtedly due to differences in the root and branching systems, respectively, to which reference will be made later.

It is also clear that, to obtain the best results with cottons of the American type, they must be grown in lines and not sown broadcast—a practice which, though advantageous, is not common with *desi* cotton, even when sown early with irrigation. Further, American cotton responds more readily to good cultivation than *desi* cotton and conversely is apt to suffer more from neglect.

Finally, the necessity of early sowing with irrigation is an important limitation, since there are few villages which in a normal year obtain enough canal water to permit of all their cotton being sown with irrigation. Further, as cotton follows wheat, it may occur that a cultivator will have difficulty in sparing time from his wheat threshing to adequately prepare land for American cotton. The latter point is not, however, of extreme importance, as the optimum time for sowing irrigated *desi* cotton is only some 10-15 days later than that for American, and earlier sowings of *desi* cotton are by no means uncommon.

It is, however, obvious that two essential conditions must be fulfilled if this crop is to be permanently established, *viz.*, (*i*) an adequate supply of irrigation water, and (*ii*) adequate arrangements for marketing *kapas* so as to ensure to the grower the true value of the improved staple which he is producing. The chief practical difficulties in assuring the first requirement lies in the fact that our great canals are organized on a protective rather than on a commercial basis, the object, necessarily perhaps, being to provide a certain amount of irrigation for the maximum

number of villages rather than to provide ideal arrangements for a limited number. The supply from the Ganges is lowest at the end of the cold weather and early hot weather, and the rise in the river (with increased supplies to the canal) consequent on the melting of the snows is sometimes late and leaves little margin before the onset of the monsoon. A minor difficulty arises from the fact that the principal branches and large distributaries, running as they do along main watersheds, do not, in many cases, command the best cotton land which is naturally situated where the drainage is best, *i.e.*, on the fringes of ravines and small rivers and therefore at the tails of distributing channels. Until 1917 there were frequent complaints from cultivators that they did not receive irrigation water in sufficient quantity or for a sufficient time to sow a full area of American cotton. While these were not in all cases well founded, many of the complaints were genuine, and the matter was therefore taken up with the Irrigation Department in order to find a method by which an adequate water supply could be guaranteed.

It was clear that the canal supplies that could be expected during May and early June would not permit of adequate water for American cotton sowings being guaranteed on all canal distributaries, and, the method of selecting villages where supplies would ordinarily be good having proved unsatisfactory, it was decided to concentrate American cotton on a limited number of channels and to ask for a special supply of water for the villages so commanded, followed by a longer closure to enable other channels to obtain adequate supplies for *desi* cotton sowings. This method was tried for the first time in 1917, and, though the increase in area in that year was by no means as marked as was expected, there was a most marked diminution in complaints and a satisfactory increase in the proportion of the crop sown at the proper time. Largely as a result of this, though partly as a result of the excellent prices obtained last year, demand for seed for 1918 sowings has exceeded the supply, and at the time * of writing the whole of the seed available has been distributed, this being sufficient for some 9,000 acres as compared to about 1,600 acres sown in 1917.

The organization of a market for unginned American cotton has been a matter of some difficulty. Whilst it is a comparatively easy matter to obtain a fair market price for any good cotton once it is ginned and baled, the same does not apply to unginned cotton (*kapas*). Throughout the United Provinces no market exists for any *kapas* other than *desi*, and buyers practically ignore staple, some attention being paid to gin-

* It has since been found that this modified system of distributing water for cotton sowings was also advantageous to *desi* cotton on the non-selected channels and led to an increased area.

ning percentage but most weight being attached to colour and cleanliness. Under these circumstances some form of buying agency for American cotton was essential, as otherwise not only would the grower have obtained no premium but the cotton would have been lost to the trade by mixing with *desi*.

In 1912-13 the Elgin Mills Co., Ltd., came forward and guaranteed a premium* of R.1 per maund of *kapas* to the grower, the department organizing the purchase and ginning on their behalf. In 1913-14 and 1914-15, arrangements were made, before the crop was sown, for the same mill to take the cotton after ginning at a price based on Liverpool spot prices for American cotton. In 1915-16 and 1916-17 similar arrangements were made with the Muir Mills Co.

These arrangements were not on the whole satisfactory to either party. In buying even limited quantities of cotton ahead, spinners naturally hesitated to guarantee a full price, especially as the department could give no guarantee as to the amount of cotton which would be offered. On the other hand, we were not in a position to pay out the full price to the grower until after all accounts had been settled, and the prices obtained in some years were not really satisfactory from the growers' point of view.

In 1917 the sanction of Government was obtained to the department purchasing the whole of the crop of Cawnpore-American cotton and putting the ginned cotton on the open market. This resulted in a premium of Rs. 4 per maund (of *kapas*) being paid to growers, a result which may be considered satisfactory, as, even with the abnormally high prices for *desi* cotton, this amounted to a premium of 25 per cent.

The spinning trials conducted by the Elgin Mills Co., Ltd., in 1912, and the valuation obtained through the courtesy of the British Cotton Growing Association in 1913, established Cawnpore-American as a cotton which was approximately equal to imported American cotton in staple and value. This has been confirmed by subsequent spinning trials and valuations and mill reports. In February, 1918, the cotton of the 1917 crop was sold in Cawnpore at Rs. 635 per *candy* (784 lb.), Bombay quotations on the same date being as follows :—

Fine Broach Spot Rs. 655, equivalent to Rs. 635 at Cawnpore.
Sind-American Spot Rs. 650, equivalent to Rs. 630 at Cawnpore.
Ordinary Broach Spot Rs. 640, equivalent to Rs. 620 at Cawnpore.
Fine Broach March-April Rs. 645, equivalent to Rs. 625 at Cawnpore.

It is clear therefore that in Cawnpore-American we have a cotton of considerable value to the trade and which can be readily sold once ginned and baled. The organization of the market for *kapas* will continue to be

* About 12½ per cent. at rates then current.

of importance until the area is large enough to induce ginners to establish a separate market. For the present year the department is continuing as last year to arrange for the marketing of the cotton.

The period 1914-1918 has been an exceptionally unfavourable one for the introduction of any improved cotton. With a record area under cotton in 1914 a severe slump in prices followed the outbreak of war, which led to a very great reduction of the area under cotton and a general lack of interest by cultivators in cotton cultivation. Our arrangements for the sale of American cotton in 1914 were entirely upset by the closing of the Liverpool cotton exchange, and new arrangements had to be made at the last moment. The premium paid to cultivators (R.1-12-0 per maund of *kapas*) was good if viewed as a percentage on the price of *desi* cotton, but the return to the cultivator was low, and while few growers gave up American, no great development took place in the following year. The 1915, 1916 and 1917 seasons were all unfavourable for cotton-growing on account of excessive rain, and market conditions were also extremely unsettled. In 1916-17 cotton prices showed a marked recovery, but the premium on American cotton was inadequate owing to imperfect marketing arrangements. At present, as already stated, owing to the excellent results of the sale of the 1917 crop and to better irrigation arrangements, much more interest is being shown by cultivators than has been the case since 1914, and a large increase in area has resulted.

II. The Improvement of Cawnpore-American Cotton.

As already stated, a preliminary examination of the Cawnpore-American crop showed that a considerable margin existed for improvement in the crop itself as regards ginning percentage, uniformity of lint, and uniformity of agricultural type. The isolation of pure races was therefore started in 1912, and this led to some unexpected results showing that the field crop was far less uniform than first appeared. In selecting plants in the field it was found that there was more variation in habit than would be expected. How far this is due to the effect of hybridization between the original importation (Upland Georgian) and subsequently introduced varieties which had been grown in close proximity to the original on the experimental farm, it is now impossible to say. A number of different types were therefore selected and studied. Avoiding extremes, some 40 plants were chosen in the field in1912, their characters recorded as far as possible, and selfed seed obtained. The progeny of these plants were individually studied in the following year and characters again recorded. As it was clear that many of the plants originally chosen were hybrids and gave rise to very variable offspring

when selfed, it was necessary to self individual plants in 1914 and again in 1915 before anything approaching to a pure line could be obtained.

The characters to which attention was paid at this stage were (1) branching habit, (2) hairiness of the leaf, (3) colour of the stamens, (4) ginning percentage, (5) length and fineness of the lint, (6) shape and size of boll, and (7), to a less extent, the leaf shape, stem colour and the colour of the foliage. The characters mentioned under (7) were of considerable assistance in the preliminary sorting of the material obtained by growing selfed seed.

The importance of the branching system of the cotton plant, in determining the length of the vegetative period and, therefore, to a large extent, the capability of yielding in the short growing season which obtains in the United Provinces, has been worked out in great detail by Leake[1] in respect to Indian cottons. The relationship of the form of the " plant scaffolding " to yield under defined conditions has also been very clearly pointed out by Balls in respect to the Egyptian cottons (which belong to the American as distinct to the Asiatic group). The literature on the habit of Upland American cottons is voluminous and confused, and it was only after considerable study in the field that the relatively simple relationships existing in the material under examination were cleared up. The various types of plants found in Cawnpore-American ranged in branching habit from the extreme sympodial type with only secondary fruiting branches to a late flowering monopodial type with numerous limbs and producing only a few flowering branches from the main stem at the top. Between these two extremes a complete range of intermediates occur, and, though the branching varies somewhat from plant to plant and is affected by environment (in particular by date of sowing and by water supply), races have been isolated which are remarkably constant in this respect. It should be noted, however, that the appearance of the plant may be very considerably modified by the development of branches from the accessory buds on the main stem. These, on the lower part of the plant at least, are usually non-flowering branches, and in wet seasons in particular such branches dev lop relatively early and tend to mask the habit of the plant. As such branches rarely throw out tertiary flowering branches early enough to contribute to the yield, and as they interfere to some extent with the setting of earlier flowers, the character, which is shown more in some races than in others, does not appear to be a desirable one. It has been pointed out by Leake[2] that, in Indian cottons invariably and in extra-Asiatic cottons usually, tertiary

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[1] " Studies in Indian Cottons." *Memoirs of the Department of Agriculture in India Botanical Series*, vol. VI, no. 4.

[2] *Memoirs of the Department of Agriculture in India, Botanical Series*, vol. IV, no. 5.

branches are of opposite character to the secondary branches from which they develop, and that apparent exceptions can be traced to local damage. In Cawnpore-American, however, certain races show a marked exception to this rule and flowering branches are found to arise from flowering branches. This character is inherited regularly and appears in all plants of a race, though in varying degree, and, when well developed, is often associated with the appearance of flowering branches from the accessory buds on the main stem particularly near the top. The character is most common among certain early types that have been isolated. At first sight it would appear to be of great economic importance as it permits of the formation of a larger number of bolls within a limited period. In practice, however, it is very doubtful as to how much it really contributes to the yield of the plant, as the flowers and bolls so formed shed freely and (at Cawnpore) the fruiting branches so formed are rarely of any length or carry more than one boll.

Length of internodes and character of the secondary fruiting branches.

These two characters are closely associated. Plants with long internodes are usually straggling in general habit and tend to produce long weak lateral branches, the lower ones of which are apt to trail on the ground.

Generally speaking, the best type for Cawnpore conditions appears to be a compact plant producing three or four ' limbs ' (secondary non-flowering branches) near the base of the main stem and with secondary flowering branches starting early, moderately short internodes and stout branches.

Length of vegetative period prior to flowering.

As pointed out by Leake[1] in connection with Indian cottons, this is closely correlated with the branching habit. The correlation is not quite so obvious in the case of American cotton as in the case of Indian cotton, as the flowering period is more extended and flowering more gradual. The date of opening of the first flower was not found sufficiently definite, being so easily varied by slight damage to the plant, but the date on which flowering from the secondary branches first became general was definite within two or three days, and this together with a record of the branching habit enabled suitable races to be isolated.

[1] *Loc cit.*

Root system.

In the course of this work it was found that some races, one at least of which was fairly satisfactory as regards lint quality, were quite as short in vegetative period as *desi* cotton, and it was hoped that this would allow of later sowings and thus get over one of the practical difficulties referred to on p. 3. This, however, does not appear to be the case. Such very early flowering types suffer severely from boll shedding in the monsoon, as a large part of the crop of bolls is produced before the end of the rains, whilst when sown later these types do not develop well. This unexpected result led to an examination of the root systems of Indian and American cottons, and abundant evidence was obtained that there is considerable difference in this respect. When sown with irrigation early enough for the plants to reach a height of 9″ or more before the burst of the monsoon, both classes of cottons developed strong root systems rooting down to at least 4′ comparatively rapidly. When sown later, but still before the monsoon, both types still succeeded in establishing themselves, though the rooting of the American was less vigorous and the plant less thrifty. When sown in more or less saturated land after the advent of the monsoon, the rooting in both cases was dwarfed, but, while the *desi* cottons still developed fairly healthy roots and were able to establish themselves, the roots of the American were short and poorly developed and the plants stunted.

The method used in examining the roots was to wash each plant out *in situ* with a jet of water, the plant being supported and also lightened by the removal of branches. As work proceeded, the roots as they were freed were supported and a rough note of their position and direction made. It was found, in all plants of appreciable age, that, although the tap-root thinned out comparatively rapidly, it continued to a very considerable depth, following a comparatively tortuous course and being practically unbranched. Little evidence of the second set of secondary roots at the end of the tap-root, such, as is described by Balls for Egyptian cotton, was obtained, but this may have been due to the fact that examination of the root systems of early sown plants was too long delayed, as it is difficult otherwise to understand the great elongation of the tap-root. The extraction of the tap-root complete, from plants of considerable age, was a matter of the greatest difficulty owing to the tortuous course which they follow, and in no case could one be positive that the whole root had been extracted. There is possibly an important field here for further work, which the authors were unable to undertake through pressure of other duties. It is not unlikely that the root systems of cotton sown before and after the beginning of the monsoon

are markedly different, since, temporarily at any rate, subsoil moisture conditions are practically reversed.

The results obtained, as illustrated by the accompanying photographs, at any rate, clearly bring out a qualitative difference between *desi* and American cotton. Photographs 1 and 45 (Plate I) show plants of Cawnpore-American of the same age (80 days), No. 1 having been sown on May 20th and No. 45 on June 15th ; the shallower rooting system of the latter is easily recognizable in spite of the fact that No. 1 was very badly extracted and many roots damaged. Photographs 9 and 17 (Plate II) show cotton plants 81 days old, all sown on May 20th, 9 being American cotton (Ca 10) and 17 *desi* cotton. In all cases the tap-root was broken off in the process of extraction, but it is clear that, when sown at this date, American cotton develops a strong and healthy downward rooting system, though somewhat less quick in developing than *desi* cotton. Numbers 10 [American] and 19 [*desi*] (Plate III) both represent the root systems of cottons 73 days old (sown on May 26th); the American cotton, if anything, has developed the better root system of the two. Photographs 14 and 15 [American] and 24 and 26 [*desi*] (Plates IV and V) represent the root systems of cottons sown on June 3rd, 14 and 24 being 66 days old, and 15 and 26, 78 days old. These roots were much more successfully extracted than those mentioned above, and the much more vigorous development of the root systems of the *desi* cottons is marked though that of the Americans is still not unsatisfactory.

Photographs 6, 13 and 23 (Plate VI) represent the roots of cottons sown on June 15th and 67 days old ; 6 is a healthy American plant, 13 a backward plant and 23 a plant of *desi* cotton. Here we appear to be approching the limit where saturation of the upper soil is interfering with the rooting of the American cottons.

Numbers 40 and 42 [Americans] and 46 and 47 [*desi*] (Plates VII and VIII) represent plants 84 days old (sown on June 15th), 40 being an indifferent plant. The massing of the roots near the surface is at once clear, the vigour of the plant above ground is reflected in its root system, and the more satisfactory development of the *desi* cotton roots is clear.

Photographs 50, 52, 53 and 54 (Plates IX and X) represent the roots of cottons sown on July 7th and 64 days old, 50 being *desi* cotton and the rest American ; 52 was the best plant that could be found in the field. The difference is here marked and much in favour of the *desi* cotton. One has only to compare these with the roots of plants of the same age and sown on June 3rd to appreciate the advantage of sufficiently early sowing for both American and *desi* cotton, but where-

as the later-sown *desi* cotton has developed fairly healthy roots the later-sown American failed to do so. Actually the remaining *desi* plants of this sowing matured properly and furnished a crop, though a poor one, whilst the American failed. In one respect the comparison is not a fair one, as in the last two sets, for want of other material, the roots of American cotton plants from newly imported seed were taken for examination. But in view of the gradually increasing difference between *desi* and American cottons throughout the series, this would not appear to invalidate our main conclusions, *viz.*, that the failure of American cotton when sown too late is due to unsatisfactory root development, and that when sown too near the monsoon the American plant develops a shallower root system than *desi* cotton, and will therefore suffer more from temporary surface water-logging (unfortunately not uncommon) and would also suffer more from a period of dry weather and hot sun following wet weather.

A reference to the rainfall graph for 1916 (facing p. 25) will show the character of the season in which these results were obtained.

Light showers which fell in May were of negligible effect, temperatures between times being high and the air dry. Heavy rain ($5\frac{1}{2}''$) fell on the 9th and 10th of June, followed by a break until the 22nd (but for showers aggregating only 0·1″) ; on the 22nd a further $5\frac{1}{2}''$ fell and wet weather continued until the 26th, followed by a break until the 6th July from which date rain was continuous until September 3rd with only a slight break in the third week in August. Thus sowings of the 3rd of June were only just up when heavy rain fell, and had barely recovered from this when very heavy rain fell. Sowings of June 15th and later were made under monsoon conditions. The monsoon was fully a fortnight earlier than the average and was unusually strong and continuous.

The middle of the monsoon period in a normal year at Cawnpore is unfavourable to cotton growing owing to over-saturation of the soil, and all cottons receive a definite check during this period. American cotton, if sown sufficiently early, recovers as soon as the rains slacken off and yields well, as does *desi* cotton. Either variety, if sown too late, fails to recover sufficiently to yield well and the American variety cannot be sown so late as *desi*.

Hairiness of the leaf.

Dharwar-American cotton and a number of imported varieties of American cotton have failed to yield at Cawnpore except in unusually dry years, and this result has invariably been associated with an attack of aphis on the varieties which failed. Examination of the leaf showed that the back of the leaf was in all cases either partially or entirely smooth,

and that plants with fully hairy leaves were free from aphis attack even when growing in close proximity with attacked plants. In this respect Cawnpore-American was practically pure, and, though some smooth-leaved races were isolated from it, comparatively few such rogues were found in the field crop. Whether the damage is entirely due to aphis or whether it is partly physiological is doubtful. In smooth-leaved cottons aphis can invariably be found on a cloudy day during the rains, but the wilting of the leaves, which is the first sign of damage to the plant, generally occurs when a period of bright sunshine follows prolonged rain, thus suggesting that excessive transpiration is in part the cause of the plants' loss of vigour. For practical purposes it was sufficient to discard all races the leaves of which were not fully hairy.

Flower colour.

All plants in the field crop of Cawnpore-American, which were examined, showed the creamy petal colour usually associated with Upland American, and no yellow petal flowers could be recognized. In all cases the flower was self-coloured, *i.e.*, no petal spot was present. In Dharwar-American, on the other hand, flowers with yellow petals were not uncommon, and the same was true of some importations grown at the same time, but, as these were all discarded for other reasons, this character was not further considered.

Stamen colour.

An unexpected result was obtained in respect to this character, a number of plants being obtained with golden yellow stamens as distinct from the pale buff usually associated with Upland American. The inheritance of this character is simple as pointed out by Balls; considerable use was made of it in the preliminary sorting, and it has been of considerable use in recognizing natural crosses. Of the pure lines which have been now obtained some show golden stamens, others pale buff, and they were easily obtained pure in regard to this character.

Ginning percentage.

As has been shown by Leake this is not a single character, but, on the other hand, the improvement of the proportion of lint to seed is an important matter since the field crop of Cawnpore-American gins from 2 to 3 per cent. below *desi* cotton, thus reducing the premium which can be paid to the grower for his *kapas*. The accurate determination of ginning percentage on small samples is no easy matter and variations are considerable, but it was possible to locate and discard certain races

which showed a low ginning percentage, and to retain others which were not only satisfactory in other characters but possessed a high average ginning percentage. It was considered that yield and lint quality were the first essentials, and by re-selection of the higher ginning individuals, from races satisfactory in other respects, it has been possible to obtain on a field scale a number of types which gin considerably higher than the original field crop. The method is admittedly inexact, but in the same way Clouston in the Central Provinces and Parr in the United Provinces were able to isolate types of *desi* cotton which show markedly higher ginning percentages than the unselected field crop. In the preliminary examination of small samples it was also found that an examination of the way in which the seed was covered enables the more constant ginning families to be recognized. The ginning percentage of cotton when grown as a field crop varies somewhat from year to year, being affected by the season, and it is the general experience of ginning factories, as also on our experimental farms, that in certain years the average is high and in others low. For this reason considerable importance is attached to the trials of the various types on a field scale which are referred to later—the more so as it has been our constant experience that the ginning percentage obtained when a cotton is grown fairly closely on a field scale is higher than is obtained from a limited number of plants grown at wider intervals to permit of individual study.

Lint quality.

A constant fault of the field crop of Cawnpore-American is the variation in the staple. The detailed examination of the lint from a number of plants showed conclusively that this was largely due to the presence of races with short and rough fibre, and several of these have been isolated pure, though subsequently discarded. Plants were found with lint as short as 0·7″, and the importance of the removal of these from a crop which was commercially graded as staple $1\frac{1}{8}$″ (British Cotton Growing Association 1913) is obvious. Fortunately it was easy to recognize at least one of these families by its vegetative characters, and consequently we have been able to rogue it out on our seed farm and it is now rarely found in the field crop. Another source of unsatisfactory lint quality, particularly in certain years, was the presence of certain late flowering types which did not mature their lint well. Such types have been discarded for this reason as well as on account of their low yield per acre, though as regards actual length of lint they have been by no means unsatisfactory. Having obtained races of uniform agricultural habit and pure in respect to more obvious characters, as many individuals as possible were grown from selfed seed and the lint of each

examined. Families showing extreme variation were discarded at once except in a few cases where unusually good lints occurred, but even these mainly resulted in disappointment. From those that showed fairly uniform and satisfactory lint, re-selections were made, and finally families which were reasonably uniform in lint characters were obtained. Length was easily determinable on the combed seed and was checked by measurement on the ginned cotton. Fineness was not so easy to determine on small samples, and it was necessary to carry on a large number of selections only to discard them later. Strength presented the greatest difficulty of all, and it was necessary to wait until sufficiently large samples were available for commercial examination before any decision could be arrived at. Generally speaking, however, it was found that samples obtained from races that ripened well were satisfactory in this respect.

The senior author is greatly indebted to several Cawnpore spinners, particularly to Mr. Vernon, of the Elgin Mills, and to Mr. Holden, then of the Muir Mills, for assistance in judging small samples, and to Messrs. Tata and Sons, of Bombay, who (at the request of the Imperial Cotton Specialist) examined a number of the selected types which were being tried on a small plot scale and whose valuations and criticisms have been of the greatest help.

Shape and size of boll.

This character has been of use in sorting out the various families, and the relation to yield is also obvious. Considerable variation was obtained in the field crop from small round bolls barely $\frac{3}{4}''$ in diameter to large pointed bolls comparable with those produced by some of the modern "Big Boll" American varieties. The races finally retained include both medium and large boll varieties, but it was found that the opening of the boll was of more importance than the size. In some races the boll opened badly, picking was difficult and the lint ripened badly; such were discarded. No attempt was made to select for five-locked bolls though these were by no means uncommon.

Method of work.

The work published by Leake, Balls and others having clearly shown that any attempt to improve cotton by ordinary selection was at best a most uncertain affair, it was decided that only by the isolation of pure lines could definite results be hoped for, and that this must necessarily involve protection from natural crossing if results were not to be entirely vitiated. This was amply confirmed in the course of the work. On a

few occasions it was necessary to sow seed produced by unprotected plants and results were in all cases unsatisfactory. As long as single plants were being dealt with these were protected by coarse mosquito nets during the principal portion of the flowering period ; bolls that set under the net were marked and only seed from these was taken for sowing in the next season. It was not possible to keep the plants under the net throughout the whole of the flowering period ; partly on account of the tendency of the plants to grow too tall and because the presence of the net interfered with the ripening of the bolls, and partly because it was impossible to net more than a limited number of plants daily. In the early stages, therefore, in order to obtain more *kapas* from each plant for examination of lint and ginning percentage, bolls from unselfed flowers were separately marked and collected.

Once a family appeared pure, a number of plants were covered with a large net so that at most they could only cross-fertilize each other, and, owing to the absence of bees, the large majority were probably self-fertilized. In this way a pure stock of seed was obtained for further multiplication on a field scale and a stock maintained from year to year.

In 1912 some 40 plants were examined in the field and netted, and selfed seed of 32 was sown in 1913 and all the progeny examined. A number were discarded by field examination in 1913, and a further series of rejections made after examination of the lints and ginning percentages. Selfed seed from 85 individuals was carried on into 1914, and in that year a few families appeared pure and a certain number of these were protected by large nets containing 20 plants (*kapas* being collected and examined singly), while other individuals were placed under single nets since it was not possible to examine the lints until it was too late to protect flowers.

In this year it was possible to reject a very large mass of the material for various reasons and 29 families were carried on under permanent numbers. Many of these were subsequently discarded, and in the case of others re-selection of individuals for lint and ginning percentage was necessary.

The most promising families were not, however, obtained pure until 1915.

The net result of this work has been to isolate from the field crop of Cawnpore-American a number of pure lines. These can be grouped under a few types as regards their agricultural characters.

Description of the various races isolated.

As stated above, rejections were freely made as work progressed, and in 1916 only 14 selections were grown out of the 29 originally brought

under permanent numbers. The remainder were rejected for various reasons, chiefly on account of unsatisfactory habit or indifferent lint. Those retained fall into four groups.

I. *Very early* : *Ca 10, 11 and 28.* These are all characterized by extremely small development of the limbs (secondary vegetative branches) ; they are in heavy flower within 54 days of sowing, depend for their yield almost entirely on the secondary fruiting branches, and are the nearest approach in habit to the local *desi* cotton that occurs amongst the Americans. Numbers 10 and 11 have characteristic red stems. The internodes are comparatively short : 10 and 11 produce small bolls, those of 28 being somewhat larger. Numbers 10 and 11 possess the fully hairy leaf ; No. 28 has now been discarded as it is not fully rough-leaved and under unfavourable conditions does badly though good enough with really good cultivation ; an attempt to obtain by re-selection from this a race with fully hairy leaf failed.

II. *Early* : *Ca 5.* This type is distinct from those described above. The plant is low and bushy ; good limbs to the number of three or four are readily developed ; and the plant is extremely prolific and shows the useful quality of setting bolls well under comparatively unfavourable conditions. The yield is largely dependent on the secondary fruiting branches, but the tertiary fruiting branches also contribute considerably. The boll is large and pointed. This race possesses flowers with golden yellow anthers and is pure in respect to this character. In respect to the development of the first flowers it is but little later than the first group, flowering commencing 54-57 days from sowing and the plant being in full flower in about 64-69 days. The secondary fruiting branches are stout and the internodes medium short.

III. *Ca 7 and Ca 9.* This pair and several others which were discarded for lint faults form a group with a slightly longer vegetative period than Ca 5, being about a week later in flowering when sown at the same time. In general habit they are somewhat larger than Ca 5, taller and with longer internodes. The boll is pointed. Flowering is more gradual and the development of tertiary fruiting branches early enough to add materially to the late yield. When sown early, vegetative branches frequently develop from the accessory buds ; and on good land in a wet season this type grows large and bushy but is still well within the necessary limits.

IV. *Medium late group* : *Ca 1, 3, 23 and 26.* These form a distinctly later group, flowering about 70 days after sowing though the earliest flowers in small numbers appear earlier. Though the number of limbs rarely exceeds four or five and the first secondary branch appears low on the main stem the plants of this group, of which 1 is the most typical,

develop large strong limbs, and the result in a wet season is the partial suppression of the earlier fruiting branches. In some years these families have yielded well and Ca 1 is perhaps the most typical of the original field crop. But as a considerable portion of the crop is dependent on the tertiary flowering branches, late sowing or an unfavourable season might result in a very poor yield—a matter which is being tested further.

Ca 23 differs from the others in habit, though similar in flowering time, and is a small compact plant with short branches and a small boll. Being apparently very hardy and possessing the fully hairy leaf in a marked degree, it was retained for a number of years but has now been discarded. The others are biggish, bushy plants with fairly large bolls, medium long internodes, and stout branches growing to a considerable height.

Theoretically these should be the best yielding group of the lot as they come into heavy flower just as the monsoon slackens off when sown at the proper time ; in practice they seem to be a trifle on the later side.

V. *Late* : *Ca 15,1 and 18.* There is a little doubt about the position of 15,1 in this grouping as it is a re-selection and in 1917 was only very slightly later than the preceding group. Ca 18 is undoubtedly a later type, flowering only occurring after 78 days from sowing.

Ca 18 is just on the limit for successful growing at Cawnpore. When sown at the usual time on good land it grows very tall and develops strong limbs with a good development of fruiting secondary branches though these are comparatively late. The tertiary flowering branches do not develop in time for the bolls to open well except in dry years.

Group V is only late in a relative sense, many far later forms were found in the process of selection from the field crop and, as they matured bolls satisfactorily in the very dry year 1913, were carried on until 1915, after which they were discarded, it being clear that they could never yield well under average conditions.

Field tests.

The next stage in the work was naturally the testing of these races for yield and commercial suitability, and the retention and multiplication of those which would appear to be the most profitable to the grower. It has been assumed from the start that it is not worth while growing American cotton at all unless a certain standard of quality can be maintained, and all really inferior types have been discarded without further trial. The same applies in a limited degree to ginning percentage, and no type was retained for multiplication with a ginning percentage inferior to the existing field crop. Subject to these limits, however, the

principal consideration is yield. Market fluctuations in India were great even under pre-war conditions, and there is a marked want of parity between the prices of cottons of different styles. Generally speaking, short staple cottons frequently command prices out of proportion to their intrinsic value. This being the case, it is clear that to depend on the extra price obtained for quality to make up for any considerable difference in yield would be most unwise. Staple and ginning percentage from the growers' point of view are both commercial qualities, both affecting the value of his *kapas*, and deficiency in the one may be made up by extra value received for the other.

The testing of the various pure lines obtained has been considerably handicapped and delayed by a series of unfavourable cotton seasons. The season 1915 was favourable to cotton until the end of August when unprecedented storms occurred, which nearly ruined the cotton crop by actual flooding and by the destruction of flowers and bolls. In 1916 an exceedingly wet year was experienced. No phenomenal falls of rain occurred but the rainfall from June to October aggregated 43″, or roughly 50 per cent. above normal, and there were practically no breaks of any length. As might be expected all varieties of cotton did badly.

In 1917 the weather until the middle of July was normal and favourable to cotton growing. The next month was unusually wet as was also the second half of September. Monsoon rainfall aggregated 38″, which was some 30 per cent. above normal, and the cotton crop was on the whole poor.

Under these conditions, with yields only some half of the normal, one can only accept the results of comparisons of yield with considerable reserve. The same applies to valuations of the cotton as under more normal conditions results might be different.

Yields in lb. per acre seed-cotton (kapas), *Cawnpore.*

No.	1915	1916	1917 I	1917 II	1917 III	1918
Ca 1 . .	685	507 : 477	496	383	...	542 : 521
,, 3 . .	...	(2) 491 : 605	585	644	451	..
,, 5 . .	582	599 (1)	666	733	426	967
,, 7 . .	...	498	522	505	384	1,110
,, 9 . .	...	461	583	(427) 491	423	927
,, 10 . .	552	410	573	...	...	..
,, 11 . .	537	507	626	637	...	765 : 802
,, 15 (15, 1) .	...	...	363	...	...	993
,, 18 . .	619	383 : 474	481	...	...	776
,, 23 . .	550	527	564	...	...	..
,, 26 . .	...	344	436	437	342	..
,, 28 . .	520	445	597	...	...	..

Kalianpur—Sowings at different dates.

No.	1916			1917					
	I	II	III	I	II			III	
	Date of sowing								
	19th May	28th May	15th June	22nd May	29th May			9th June	
Ca 1 . . .	423	354	253	498	415	335	305	226	270
„ 5 . . .	521	638	302	600	516	417	496	309	376
„ 11 . . .	613	531	355	542	544	374	439	323	340
„ 18 . . .	395	...	313	415	439	387	358	121	245
„ 23 . . .	583	...	452	481	550	439	...	301	413
„ 28 . . .	518	484	151	424	391	327	278	160	265

In 1917, seed being available, the following numbers were grown on a field scale and gave the following yields :—

No.	*Kapas* per acre
	lb.
Ca 5	61
„ 11	551
„ 1	413
„ 18	371
Ordinary Cawnpore-American	416, 419, 457

In considering the yields for sowings at different dates, the dates on which the monsoon commenced in the two years concerned, *viz.*, June 9th and June 16th respectively, must be allowed for, both these being earlier than the normal and this being distinctly to the disadvantage of the late sown crops. In each year the rainfall in June and July was above the average.

The following table shows the ginning percentage and the length of staple as determined at the experimental farm for the years 1915-1917 :—

Ginning percentage and length of staple determined at the Kalianpur farm for the years 1915-1917.

Groups.	Ca	Ginning percentage			Lint length			Abstract of Tata & Sons' Valuation					
								1915		1916		1917	
		1915	1916	1917	1915	1916	1917	Count (Warp)	Class	Count (Warp)	Class	Count (Warp)	Class
I	10	31·9—32·2	32·0	31·9	0·95	0·95	0·9-0·95	16	IV	10	IV	...	...
	11	33·3—33·9	32·9	32·5	1·05	1–1·05	1·00	16	IV	16—20	II	30	II
	28	31·4—32·2	31·8	32·0	0·90	1·05	0·90	24	II	12—14	III	30	II
II	5	35·5	34·5	34·0	0·95 C	0·95	0·95	16	IV	12—14	III	16	IV
III	7	...	33·1	33·3	1·15	1·05—1·10 F	1·05 F	...	...	24	I	30	II
	9	...	33·4	33·2	1·15	1·05—1·10 F	1·10 F	...	...	24	I	40	I
IV	3	...	35·3	34·0	...	0·90 C	0·90 R	...	...	12—14	III	16	IV
	23	33·0—33·3	31·1	32·3	1·05	1·05	1·05	20	III	10	IV	30	II
	1	31·3—32·0	32·0	31·5	1·00	1·00 R	1·00	20	III	12—14	III	20	III
	26	31·4	32·7	32·5	1·05	1·05—1·10	1·00	...	...	20	II	20	III
V	15, 1	...	...	34·7	1·10	1·10	1·05	...	...	20	IV	30	II
	18	31·0	32-34 Var.	32-34	1·15 F	1·15	1·10	20	III	10	IV	40	I

F=Fine. R=Rough. C=Coarse.

We are indebted to the courtesy of Messrs. Tata Sons & Co., Bombay, for the following commercial valuation and detailed reports on the various cottons.

1915 crop.

Price basis.—All prices in rupees per candy of 784 lb.

Ordinary Sind-American	310	Kumpta	345
Good Sind-American	325	Navsari	375
Saw-ginned Dharwar (American)			320
Madras Cambodia			365
Ordinary Cambodia			334

Ca 2 will spin 30's warps	340
„ 28 „ 24's „	330
„ 1, „ 17, „ 18, „ 23 „ 20's „	325
„ 10, „ 11, „ 5 „ 16's „	310

1916 crop.

Price basis—

Saw-ginned Dharwar	390	Fine Surat	425
Fine Broach	390	Navsari	450

Group I—

Ca 9, „ 7 good for 24's warps strong and uniform; Ca 9 a little superior in length	410

Group II—

(*a*) 26, 15, 1 will spin 20's warps	395
(*b*) 14, 11 „ 16–20's „	385

All tolerably long in staple but fibre weak and not uniform Ca 11 and 14 being very irregular.

Group III—

Ca 3, „ 2 will spin 12's—14's warps	370
„ 1, „ 5, „ 28 All short but uniform	360

Group IV—

Ca 18, „ 23, „ 10 Good for spinning 10's warps, 18 the best and fairly uniform, the rest variable: all weak	310

1917 crop.

Price Basis—

Navsari	785		
Sind-American	720	Surat	753
Saw-ginned Dharwar	700	Fine Broach	725

Group I—

Ca 9, „ 18 Good for 40's warps, almost equal to Navsari	785

Group II—		
Ca 7, „ 11, „ 15, 1, „ 23, „ 28	Good for 30's warps, may be compared with Surat	755
Group III—		
Ca 1, „ 26	Good for 20's warps, equal to Fine Broach	720
Group IV—		
Ca 3, „ 5	Good for 16's warps	700

All the samples are good in strength except 15,1 which is a little weak and fine soft and silky.

NOTE—

1915 and 1916	Samples were hand-ginned.
1917	Samples (except 15,1) were from fair-sized plots and were all machine-ginned (Platt's roller gin).

In considering these results one is at once struck by the effect of season, the effects of the phenomenally wet season of 1916 being to reduce the quality in all cases and to produce weak cotton on the whole.

Ca 9 stands out as the best throughout in respect of lint quality, is satisfactory, though not the best, in point of ginning percentage, and is also a good yielder. Ca 5 is the most consistent yielder and has the highest ginning percentage but is in the lowest class as regards quality. Ca 7 is but little inferior to Ca 9.

Certain of these selections have behaved very irregularly as regards lint quality. Thus Ca 18 was very fair in 1915, bad in 1916, and equal to the best in 1917. This variation appears to be closely related to its late ripening habit.

Ca 11 has done better in 1916 and 1917 than in 1915 but requires further trial. Ca 28 has also been variable but has been discarded for other reasons as also 23.

Through the courtesy of Mr. F. Hodgkinson, of the Indian Cotton Committee, the following valuations of samples from the 1917 crop, by the expert brokers to the British Cotton Growing Association, have been obtained :—

"Ca 1 22d.	Good colour, about good middling in grade, staple 1″ to 1 1/16″ rather mixed.
„ 3 21d.	Good colour, good middling in grade, rather rough, staple 3/4″ to 7/8″.
„ 5 21·50d.	Rather dull, barely good middling, 7/8″ to 1″ staple.
„ 7 24·50d	Good middling, strong and silky, staple 1 1/8″.
„ 9 24·50d.	„ „ „ „ „ 1 1/8″.
„ 11 21·50d.	„ „ good colour, 1″ to 1 1/16″ staple.
„ 18 24·50d.	„ „ good colour, 1 1/8″ staple.
„ 26 23·00d.	„ „ good colour, 1 1/16″ staple.
„ 28 21·00d.	„ „ good colour, staple 3/4″ to 7/8″

"All based on July American futures 22·00d. per lb., good middling American 21·56d. per lb.

"The Ca 7, 9, 18 are very good and are cottons which could be used extensively in Lancashire, and if India could produce any quantity there should be an excellent demand. Of course you will understand that prices are abnormal and that it would not always be possible to obtain a basis of 250 points *on* for such cotton. Probably 70 to 100 points *on* would be nearer the mark. No. Ca 26 is also a fair cotton, and could be used, but not to the same extent as the others.

"These samples are of course a great improvement on the samples of Punjab-American 4F."

From the above report it is clear that most of these cottons would fetch prices equal to American in Lancashire, and that three of them are in every way suitable for Lancashire requirements. In the British Cotton Growing Association report of 1913, the unselected Cawnpore-American was graded as low middling American with a staple of $1\frac{1}{8}$", silky, strong but irregular. In Ca 7, 9, 18 the length of lint has been maintained without the irregularity which was undoubtedly due to a mixture of races.

The field testing of these groups is still in progress, a series of test plots having been sown at different dates over a period of a month or so. Results up to the present would indicate that the families 5, 7, 9 are the most likely to be really good yielders under average conditions. Earlier types flower too freely before the end of the rains and in most years lose a lot of bolls by shedding, later types do not mature a sufficient proportion of the bolls formed on the tertiary fruiting branches, on which they are largely dependent for their yield, before the cold weather.

It is at any rate of interest to note that a set of selections of consider able value have been obtained and that the best of them are suitable for spinning much higher counts than was considered feasible[1] with the unselected field crop. The apparent suitability of these cottons for relatively fine warps is of particular importance.

III. Trials of New Importations.

Concurrently with the attempts, which have been described above, to improve Cawnpore-American cotton by the selection of pure lines, a number of recent importations have been tried. In 1912, the following varieties obtained through the kindness of Mr. Henderson (then Deputy Director of Agriculture, Sind) were grown :—

Toole, Texas Big Boll, Black Rattler, Boyd's Prolific, Allen's Long

[1] Reports of Elgin Mills spinning trials. *The Agricultural Journal of India*, vol. VIII, pt. IV, 1913.

Staple and Peterkin. To these were subsequently added Griffin and Triumph.

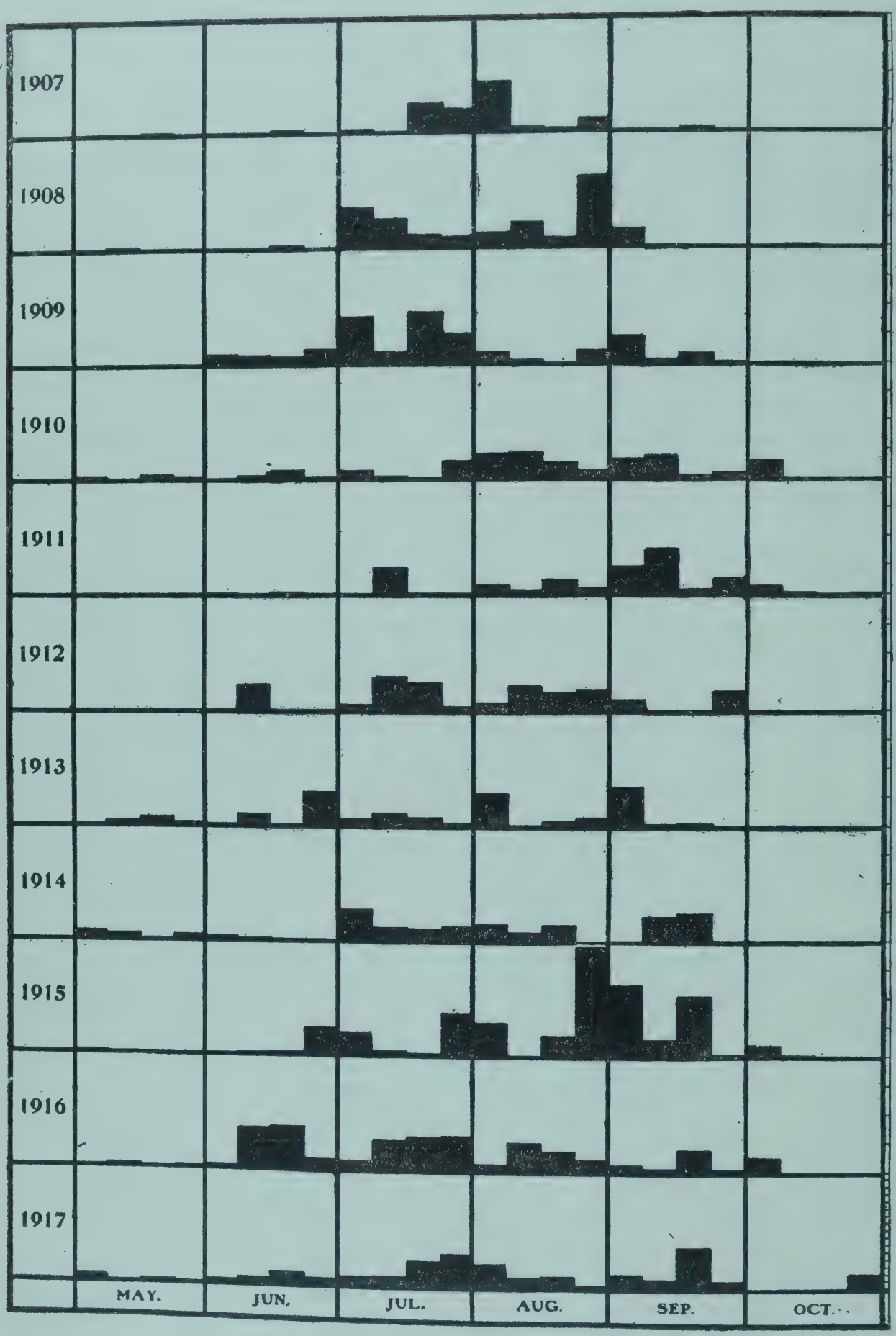
A number of " acclimatized " American cottons were also tried, *viz.*, Dharwar-American, Buri, and some Lyallpur-American selections kindly supplied by Mr. Milne. None of these cottons did well in 1912 which was a fairly favourable season, and Cawnpore-American stood out as the best. In 1913 with a very dry season many of the imported Americans yielded extremely well. Simultaneously with the field trials of these imported cottons, an attempt was made to isolate from them the races best suited to our conditions, since they were none of them homogeneous, and it was thought that this method might lead to more definite results. In particular an attempt was made to isolate rough leaf types. These efforts only resulted in disappointment. In 1913 all cottons grew well and it appeared that stapled varieties like Black Rattler could be successfully grown, and types of plant which in general habit differed little from Cawnpore-American were picked out. But in the subsequent wet seasons these all went down with aphis and the usual " red leaf " damage that follows.

In 1914 a further importation of modern American varieties was made and the following varieties were tried :—Columbia, Foster, Durango, Trice. All these were excellent for our conditions in branching habit and date of flowering, but all went down with aphis and all possessed a smooth leaf. In this year two selections from Black Rattler and Boyd's Prolific showed promise but failed later.

In 1917 some more new importations from America were tried, *viz.*, Cleveland Big Boll, Cook, Simpkin's Ideal, Perry, King and Myatt's Early Prolific. These failed in the same way as earlier importations and were dropped.

Dharwar-American. As a field crop this had proved inferior to Cawnpore-American in 1911, but some selections were made from it and carried on for a number of years, since Dharwar-American is an old established crop in Bombay and is believed to have been originally New Orleans while Cawnpore-American is believed to have been Upland Georgian. The field crop was unsatisfactory on account of the large number of smooth-leaved plants, but it was possible to find rough-leaf types. These were discarded later, being inferior to those obtained from Cawnpore-American in other characters.

Buri. Seed of this cotton, the origin of which is not very definitely known but which may have been imported at the same time as the lots from which Cawnpore-American and Dharwar-American originated, was obtained from Aligarh where in dry years it had been showing some promise. At Cawnpore, except in 1913, it was unsatisfactory on account



Block by Government School of Arts and Crafts, Lucknow.

Chart showing monsoon rainfall at Cawnpore.

of its long vegetative period and late flowering, the plant growing large and bushy but producing little cotton. Nor was it possible to isolate an earlier race from it. The fault appeared to lie in the general habit of the plant, since even when sown early it did not cease vegetative growth and develop flowers early enough to yield well before the cold weather set in. This cotton clearly requires either drier conditions than exist at Cawnpore in an average year or else a later cold weather resulting in a more lengthy fruiting period.

Lyallpur-Americans. These appeared to be too long in vegetative period and too bushy in habit for our conditions and were dropped after the second year's trial. This was not unexpected as American cotton occupies a different place in the rotation in the Punjab canal colonies to what it does in the United Provinces, and it was hardly likely that a cotton selected to suit those conditions would also do well at Cawnpore.

These results, though negative, are of importance as showing the danger of wholesale importations of exotics. Whether their failure is entirely due to their lack of the hairy leaf is uncertain, but it is significant that most of the types tried were satisfactory in all other readily recognizable characteristics.

IV. Variations in Climatic Conditions from Season to Season.

As pointed out by Leake and Parr [1], the cotton-growing season in the United Provinces is characterized by its relative shortness, and this is aggravated by the nature of the rainfall during the middle period during which rain is so heavy that the soil is more or less constantly waterlogged and a definite check to the growth of the plant occurs. A reference to the table for weekly rainfall (Appendix II) and to the graphs for same (*see* opposite) will show that in the past ten years there has been very considerable variation in the course of the monsoon. Thus the first rainfall has been received any time between the first week in June and the middle of July, and there have been equally considerable variations in the subsequent course of the monsoon. It is generally recognized that for irrigated cottons near Cawnpore the less the rainfall the better the crop, and for cottons sown with the rains the same is roughly true, provided there is enough moisture at a sufficiently early date to permit of sowings, and that the crop receives enough rainfall during the early part of the monsoon to establish itself. Thus the two best recent years as regards cotton yields have been 1908 and 1913 when the irrigated crop was exceptionally fine and yields as high as 500 lb.

[1] *The Agricultural Journal of India*, vol VI, pt. I.

per acre of *ginned* cotton were obtained. Such seasons are, however, the exception and are only mentioned because in such years almost any cotton will yield well, and the results obtained may consequently be very misleading since under these conditions not only are yields unduly favourable but the habit of the plant is appreciably modified and late types do unusually well since they receive no check in growth.

Generally speaking, our monsoon can be divided into three periods, so far as cotton is concerned, and damage in one or the other by excessive rain must be expected, whilst in some years, such as 1916, rain may be excessive throughout, continuous wet weather being more disadvantageous to cotton than heavy falls with marked breaks.

The year 1915 is an example of a season favourable as regards the initial period and unfavourable at the end but presenting no unusual features in the middle period. With light rain up to the middle of July all types of cotton made a good start. The second period with considerable though not very excessive rainfall encouraged considerable vegetative growth. But the third period was disastrous and the heavy storms and generally wet weather then experienced resulted in the loss of nearly two-thirds of the crop. Not only were flowers destroyed and bolls prevented from setting, but the waterlogging was so severe as to cause the shedding of early bolls which were already well developed, and the plants were generally weakened.

The converse effect is perhaps best seen in 1912 when rainfall was considerable in the early stages and late sown crops were only established with difficulty, but the rainfall in September was light and the crop was on the whole good though there was a tendency to excessive vegetative growth.

The above considerations, coupled with the fact that cultivators' land is as a rule inadequately drained—being unfortunately often incapable of any radical improvement in this respect with our present system of holdings—make it clear that resistance to waterlogging is a primary essential for any cotton that is to be established in this part of the United Provinces. There seems no method of testing this other than by careful field trials of pure lines coupled with detailed observation over a series of years. It is for this reason that so many types have been retained and that their testing is not yet completed.

V. Cultivation Experiments.

From 1912 onwards a series of experiments on the cultivation of American and *desi* cottons were carried out at the Kalianpur farm, Cawnpore. It is only proposed to give the general conclusions arrived

at here ; for details the reader is referred to the annual reports of the experiment station.

I. Early cultivation.

In the United Provinces cotton commonly follows wheat and very little cultivation is given prior to sowing, the usual practice being to plough for the first time when the land is flooded before sowing. A series of careful experiments showed that much better results were obtained if the land was flooded and ploughed immediately after the wheat harvest, and left as a broken fallow until sowing time instead of being allowed to bake hard until just before sowing. Also although this involved two floodings instead of one, there was an advantage even from the irrigation point of view in early ploughing, since sowing time is the period of greatest pressure on the canal supplies and a broken fallow was found to require less water than an unbroken fallow. Early ploughing was equally advantageous for *desi* cotton. This result is what one would anticipate, but the practice of early ploughing is difficult to introduce as both men and cattle are then fully engaged in threshing operations.

2. *Line* versus *broadcast sowing.*

Desi cotton in these provinces is usually sown broadcast though sowing in line is undoubtedly better—at least for irrigated cotton. In the case of American cotton sowing in lines is almost essential if the best results are to be obtained, as otherwise thinning and weeding are badly carried out and a large number of plants are badly developed in consequence.

With really good cultivation and careful sowing a distance of $3' \times 3'$ is hardly too much from plant to plant, but on the whole a distance of $3' \times 2'$ in really good fields and $2'\ 6'' \times 1'\ 6''$ in average fields has proved most satisfactory. With wider plantings there is the risk of loss of yield through imperfect germination (to which cotton is particularly liable) or through poor development in an unfavourable season.

3. *Ridge* versus *flat sowing.*

When cotton is sown in lines in the United Provinces the country plough is generally employed, the seed being dropped by hand in the shallow furrow so formed. Ridge sowing on the Egyptian system was tried for two years and at first showed some prospects of success, but generally the germination was not so satisfactory as by the commoner method ; no proportionate advantage to the plant was recognizable and the additional cost of labour was considerable.

4. *Late* versus *early thinning.*

The quantity of cotton seed usually sown is far in excess of the quantity required to produce the required number of plants, though much smaller than is common in America. With a decent germination fully ten times as many plants come up as are required and singling and thinning are necessary. Several recent American writers have recommended that the "chopping out" or final thinning should be postponed as long as possible with the object of discouraging excessive development of secondary non-flowering branches. This method was tried in comparison with the ordinary method for three years but with unsatisfactory results. In general it was found that plants so crowded in their early growth did not recover vigour satisfactorily and that the best results were obtained when thinnings were carried out gradually and as early as was consistent with ensuring a full stand.

5. *Intercultivation.*

It is the custom in the United Provinces to weed cotton by hand, two or three weedings being usually given. Better results are obtained by the use of the bullock hoe or cultivator in the early stages, as this is not only cheaper but also much more effective in opening up the soil and by its slight ridging effect assists drainage between the rows. A simple and inexpensive type of cultivator has been introduced for the purpose.

VI. Summary.

When sown sufficiently early with irrigation Cawnpore-American cotton is in no way inferior in average yield to *desi* cotton sown under similarly favourable conditions. Given adequate marketing arrangements it fetches a much better price than *desi* cotton and is profitable to the grower.

In order to establish any considerable area special irrigation arrangements are necessary as the possible sowing time is short and well defined.

Given adequate irrigation facilities and suitable organization for marketing, there is every reason to believe that a considerable area of Cawnpore-American cotton can be profitably grown in some of the canal districts of the United Provinces.

The field crop of Cawnpore-American cotton was found to be a mixture of different races of very varying value. A number of these have been isolated, the best of these have been grown on a field scale, and choice has now been narrowed to a few which require testing in a normal season. These pure races are superior to the field crop in yield, ginning percentage and uniformity of staple.

All newly imported cottons tried have given unsatisfactory results. This appears to be due to the fact that none of those tried possessed a fully hairy leaf.

It is possible that with the experience now gained it will be possible to isolate a better cotton still from the field crop but this is a matter of conjecture only. Several races with staple (1 $\frac{1}{8}$″) above average American have been obtained. If a cotton of longer staple is required it will probably have to be produced by hybridization.

In conclusion the senior author wishes to acknowledge his particular indebtedness to Mr. Leake, Economic Botanist to Government, United Provinces, for his ever ready assistance in the course of this work and for much friendly advice; also to Messrs. Tata Sons & Co. for invaluable assistance in the commercial valuation of the various cottons under trial.

APPENDIX I.

Note on 1918 results.

While this bulletin was in the press some results from the 1918 crop have become available, and certain of these have been incorporated in the text. The year 1918, though extremely abnormal, was more favourable to irrigated cotton than either of the three preceding years. As will be seen from the subjoined table, rainfall was extremely low, the season being the driest for some 40 years. Results obtained in such a season have naturally to be accepted with some caution as the crop was entirely raised on irrigation and yields were largely determined by success in timing the waterings—a point on which we have no previous experience at Cawnpore to guide us.

At the Kalianpur farm Ca 9 was the most consistent yielder on a large scale: the results from plots sown at different times were as follows:—

Yields of unginned cotton (kapas) *in lb. per acre.*

	First sowing May 14th		Second sowing May 24th		Third sowing June 10th	
Ca 1	682	488	556	498	616	657
Ca 5	587	742	575	763	707	853
Ca 7	582	587	661	755	661	725
Ca 9	494	602	602	694	668	746
Ca 11	461	513	621	658	685	701
Ca 15,1	585	740	595	703	633	815

At the Experimental Farm, Ca 5, 7, 9 and 11 have all yielded well.

Rainfall during 1918, in inches.

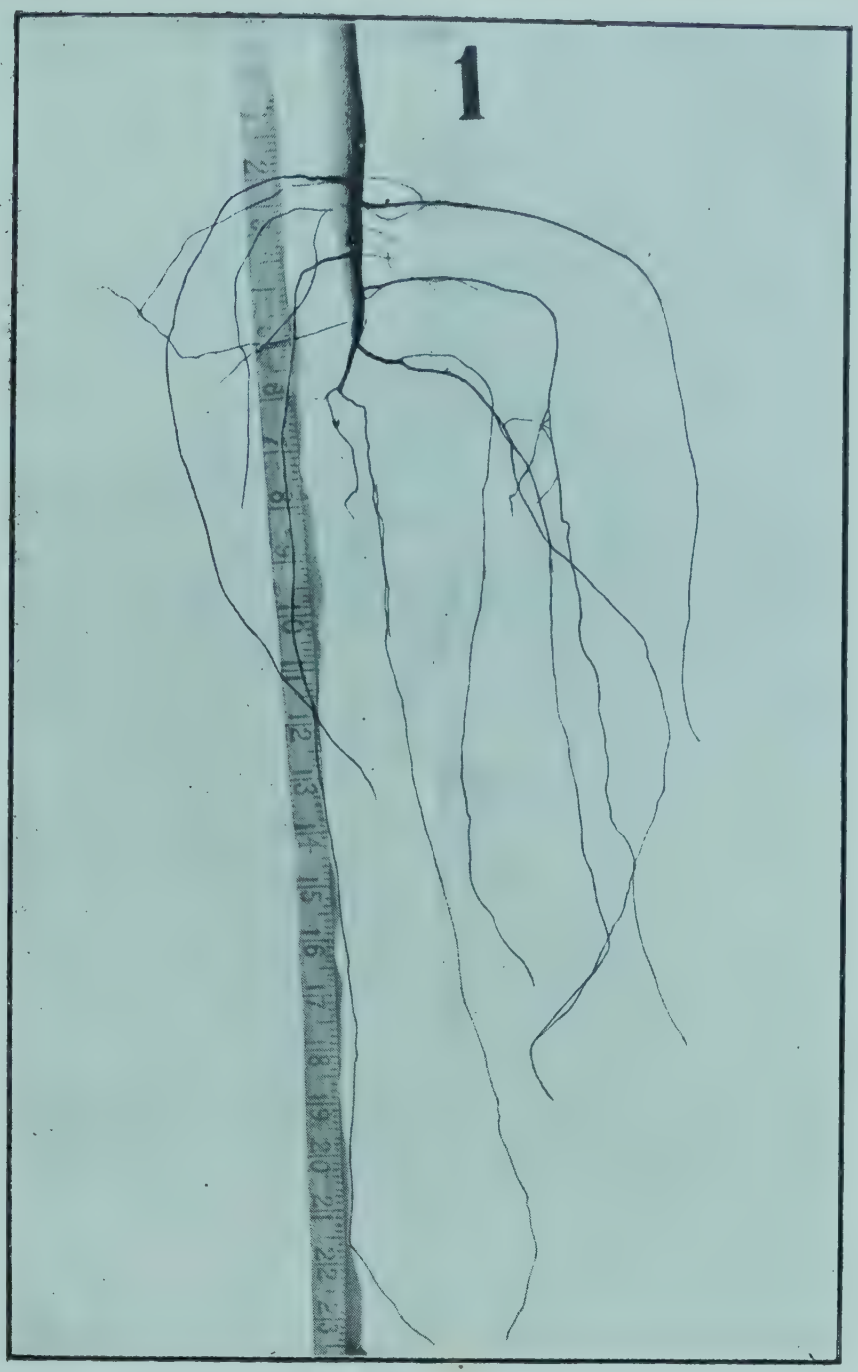
May—	
1st to 7th	0·28
8th to 15th	nil
16th to 23rd	nil
24th to 31st	nil
June—	
1st to 7th	0·65
8th to 15th	0·17
16th to 23rd	nil
24th to 30th	0·91

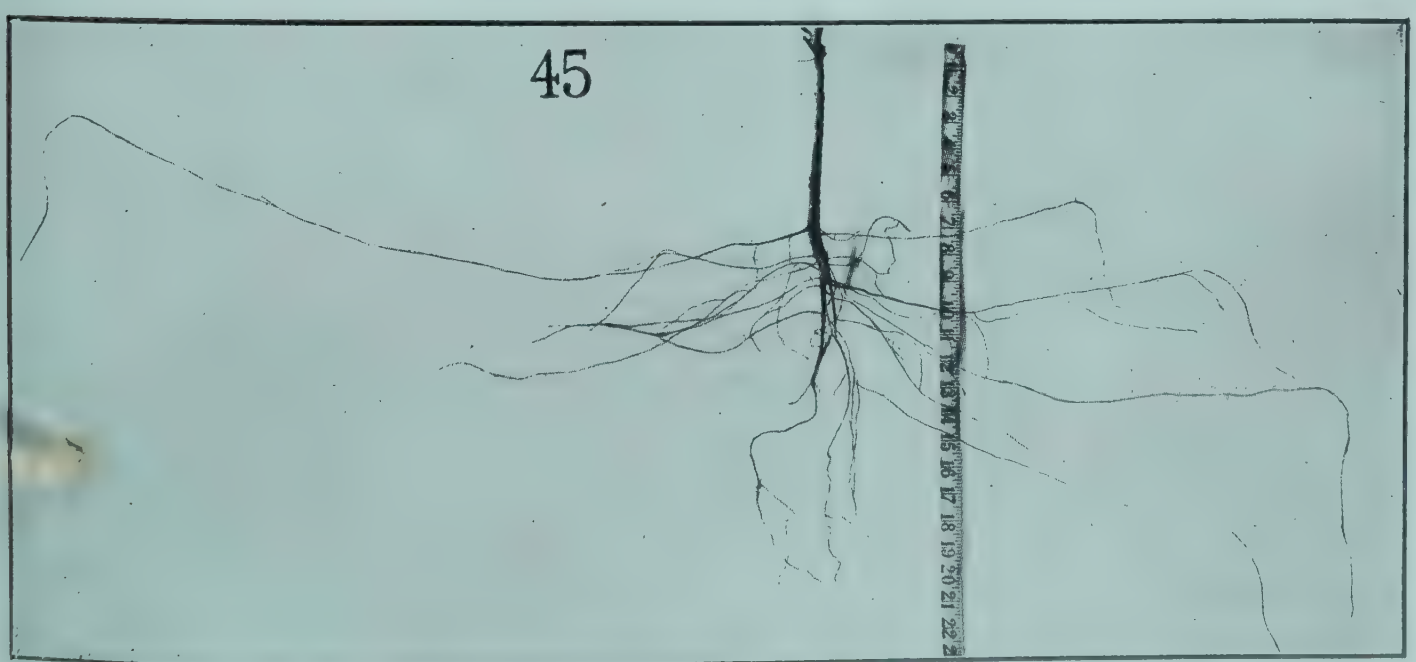
July—	
1st to 7th	0·25
8th to 15th	0·78
16th to 23rd	0·19
24th to 31st	0·24
August—	
1st to 7th	0·01
8th to 15th	nil
16th to 23rd	3·13
24th to 31st	2·17
September—	
1st to 7th	1·28
8th to 15th	nil
16th to 23rd	nil
24th to 30th	nil
October	nil
TOTAL	10·06
Normal	31·51

APPENDIX II.

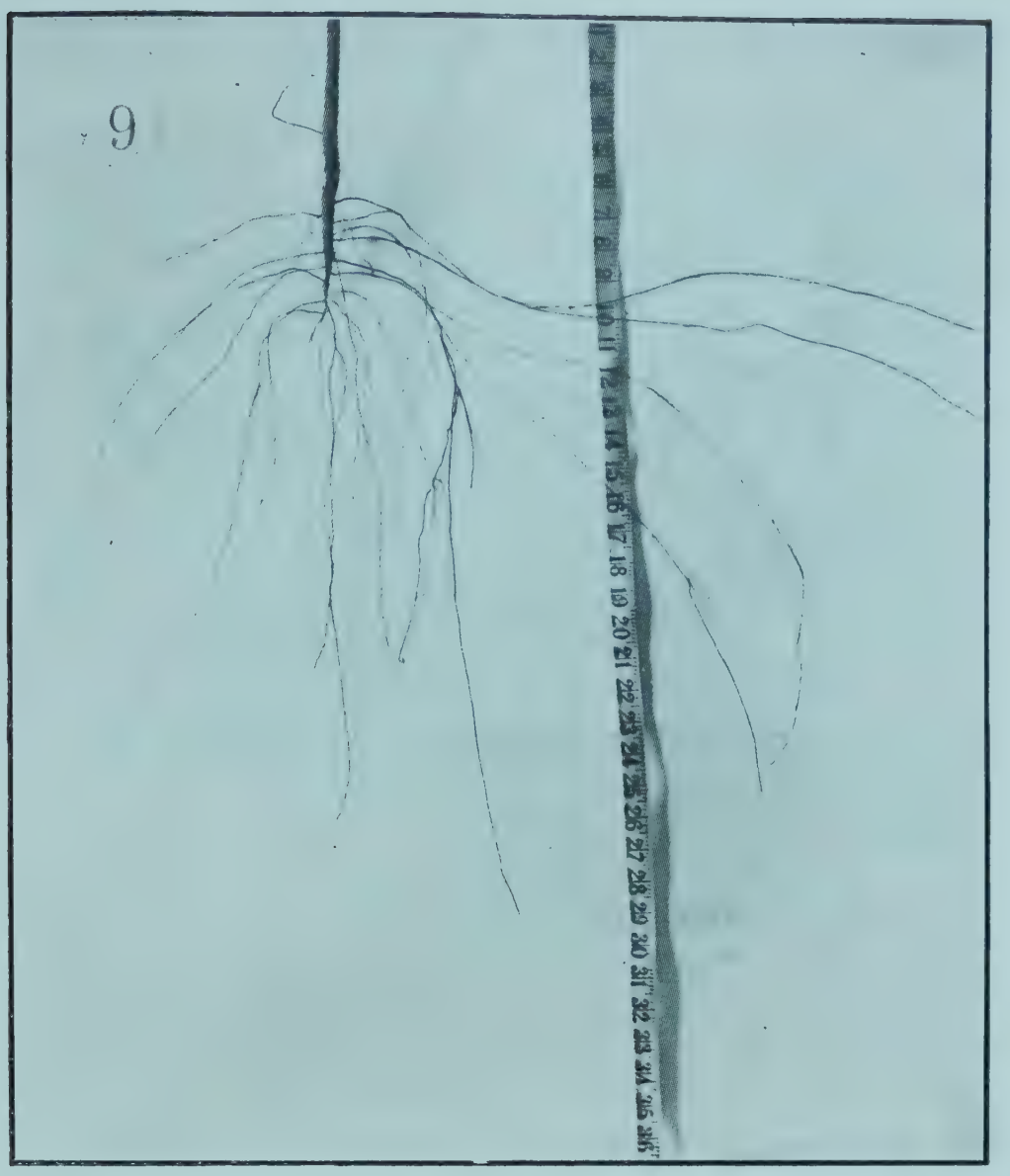
Monsoon Rainfall, 1907-1917 (Cawnpore) in inches.

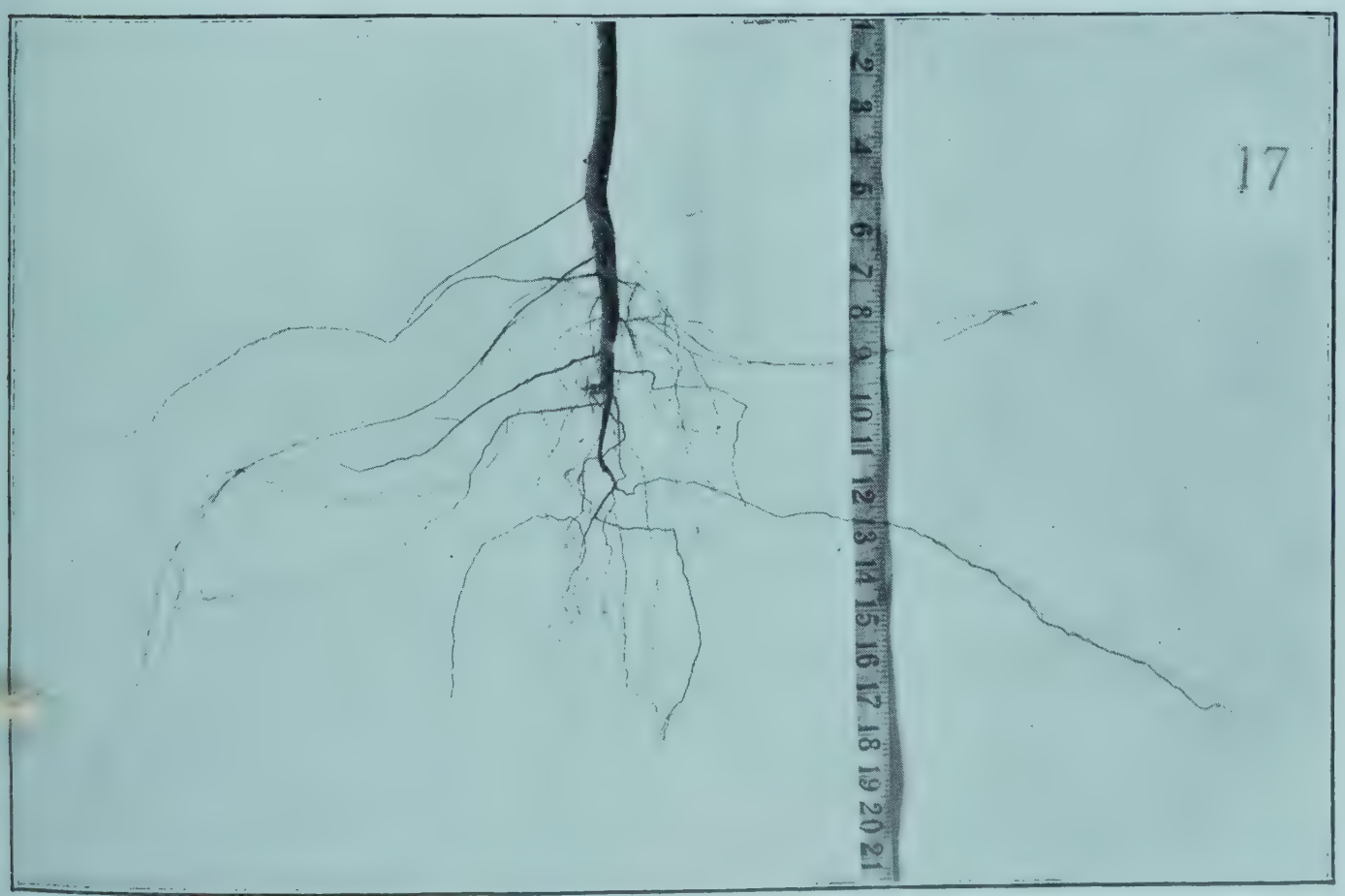
Month	1917	1916	1915	1914	1913	1912	1911	1910	1909	1908	1907	Average
May—												
1st to 8th	0·51	...	0·03	1·08	...	...	...	0·22	...	...	...	0·17
9th to 15th	0·01	0·08	...	0·64	0·46	...	...	...	...	0·15	...	0·13
16th to 23rd	0·08	...	...	...	1·00	...	...	0·50	...	...	0·16	0·16
24th to 31st	0·02	0·02	...	0·50	0·23	...	...	0·19	...	...	...	0·09
June—												
1st to 8th	0·37	0·18	...	0·33	...	...	0·03	...	1·36	...	...	0·21
9th to 15th	0·61	5·58	0·01	0·07	1·54	3·64	...	0·45	1·20	...	...	1·19
16th to 23rd	1·50	5·70	0 08	...	...	...	0·04	1·07	1·05	0·19	0·18	0·89
24th to 30th	0·86	1·32	3·77	...	4·62	...	...	0·11	2·08	...	...	1·16
July—												
1st to 8th	1·22	1·16	3·09	4·27	0·84	0·81	...	1·01	6·45	5·53	0·36	2·25
9th to 15th	1·33	3·98	0·48	1·83	1·61	4·84	3·59	0·13	1·57	3·86	...	2·11
16th to 23rd	3·42	4·58	0·02	1·80	1·00	3·97	0·04	0·08	7·14	1·77	3·86	2·52
24th to 31st	4·68	4·62	5·82	2·03	0·21	0·58	...	2·47	4·01	1·62	3·21	2·66
August—												
1st to 8th	3·30	0·79	4·46	2·39	4·51	1·22	1·15	3·45	1·58	1·90	6·86	2·87
9th to 15th	1·30	3·78	...	1·24	...	3·41	0·41	3·61	0·33	3·42	0·42	1·63
16th to 23rd	1·65	2·84	2·83	2·30	0·49	2·63	2·04	2·29	0·01	1·21	0·29	1·69
24th to 31st	0·31	1·57	15·10	...	1·13	2·93	0·76	1·14	1·73	9·57	1·80	3·28
September—												
1st to 8th	2·00	0·91	9·77	...	5·42	1·55	3·78	2·72	3·60	2·42	...	2·92
9th to 15th	1·48	0·45	2·28	3·55	0·07	...	6·34	3·32	0·40	...	...	1·67
16th to 23rd	5·89	3·02	8·24	3·79	0·12	...	0·62	0·38	1·34	...	0·17	2·14
24th to 30th	1·16	0·30	0·07	...	...	2·54	2·35	0·89	0·10	...	...	0·67
October—												
1st to 8th	0·02	1·93	1·63	...	...	...	1·16	2·51	...	...	...	0·66
9th to 15th	...	...	0·02	...	...	...	0·20	...	..	0·04	..	0·24
16th to 23rd	...	...	...	...	...	...	...	...	...	...	...	...
24th to 31st	2·21	...	...	...	...	...	0·01	...	...	...	...	0·20
											TOTAL	31·51



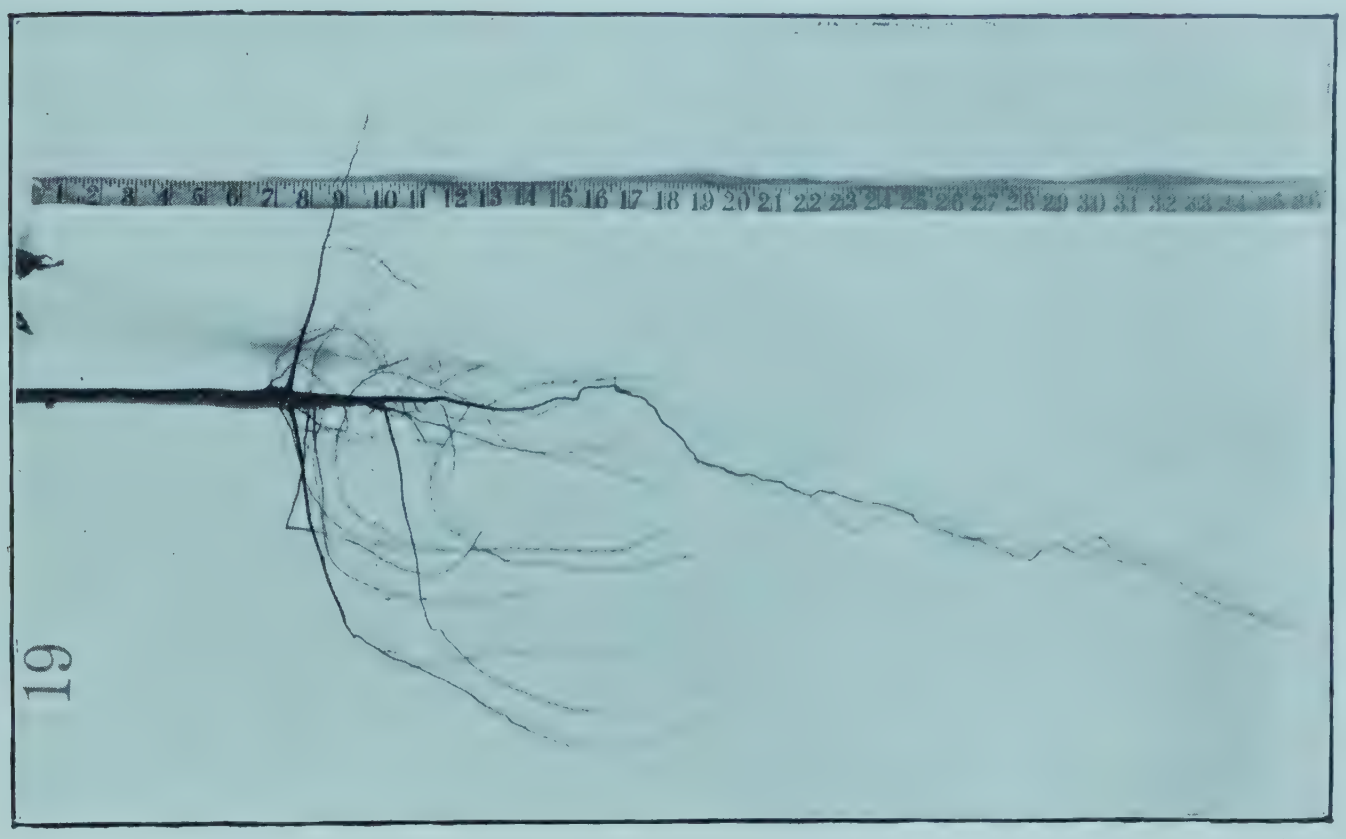


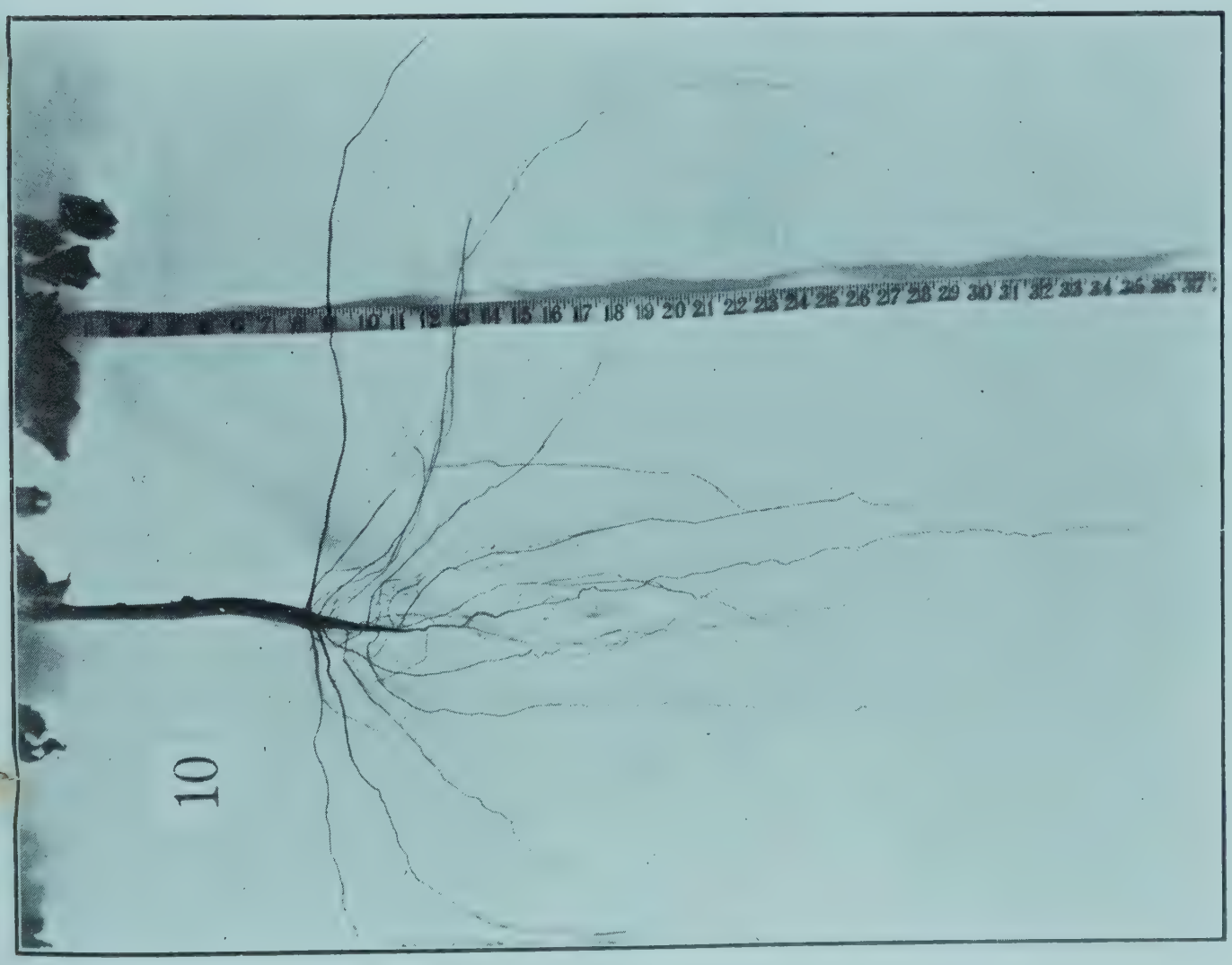
Root systems of Cawnpore-American plants of the same age (80 days); No. 1 sown on 20th May and No. 45 on 15th June.



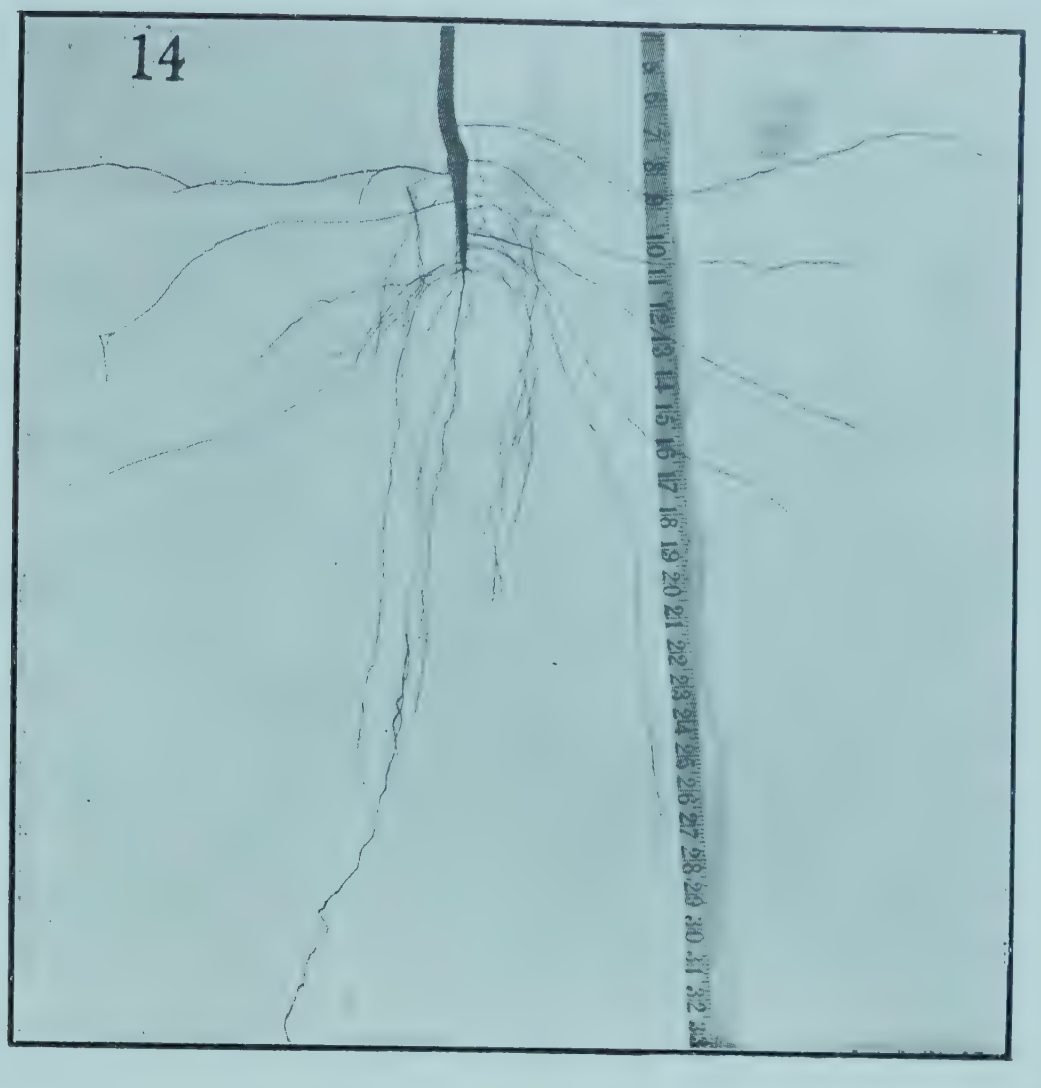


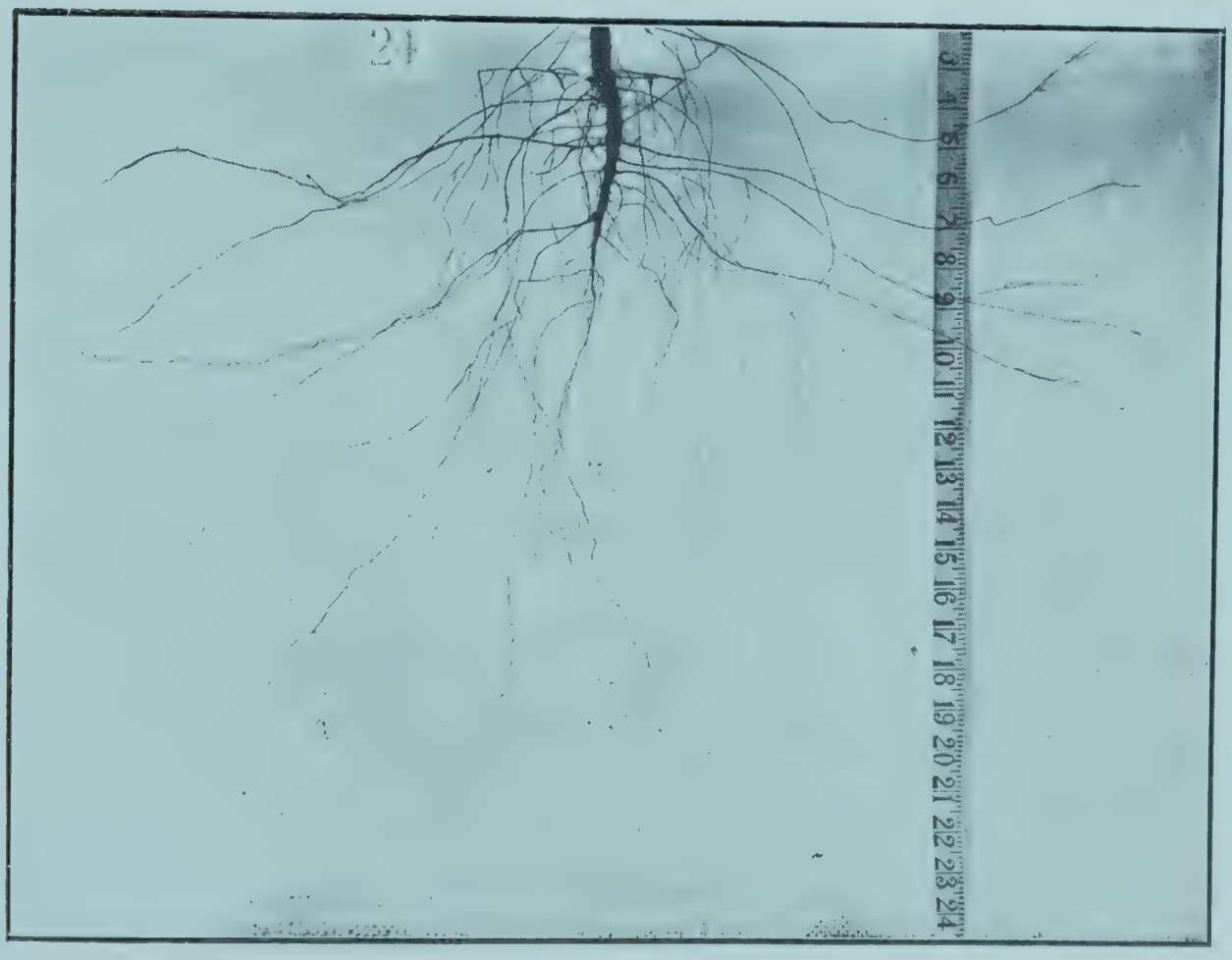
Root systems of Cawnpore-American (No. 9) and *desi* (No. 17) cotton plants, 81 days old ; both sown on 20th May.



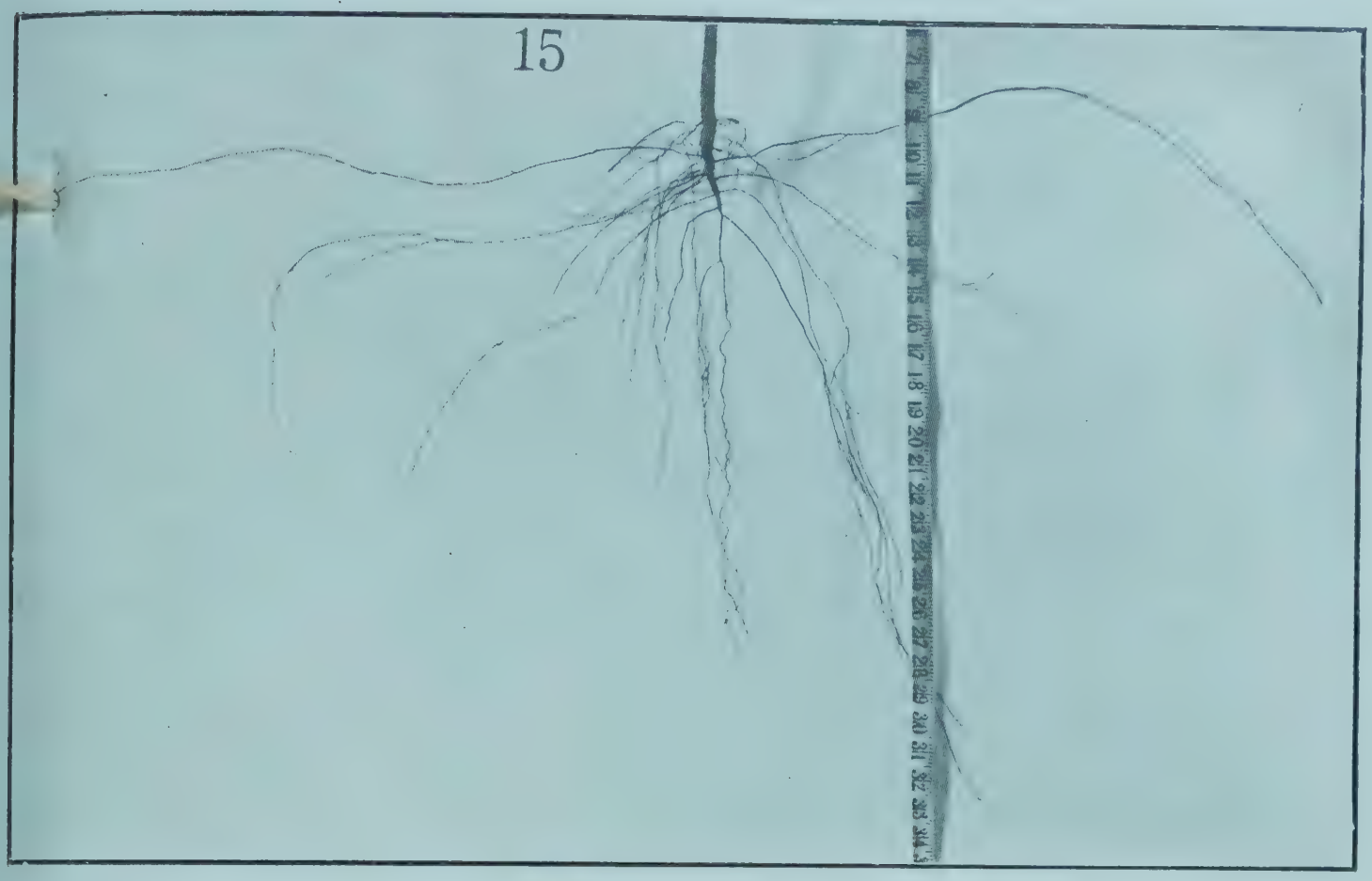


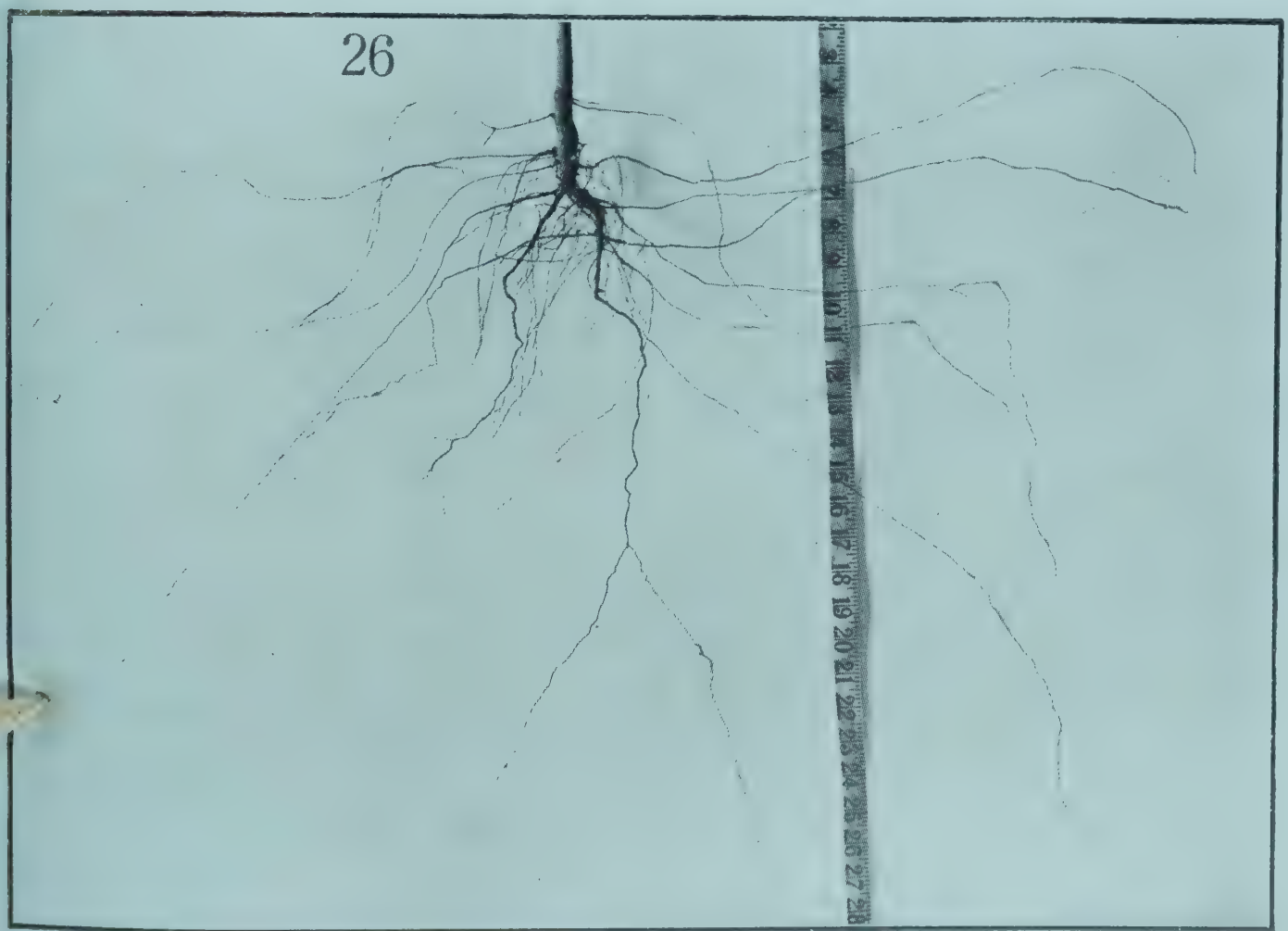
Root systems of Cawnpore-American (No. 10) and *desi* (No. 19) cotton plants. 73 days old; both sown on 26th May.



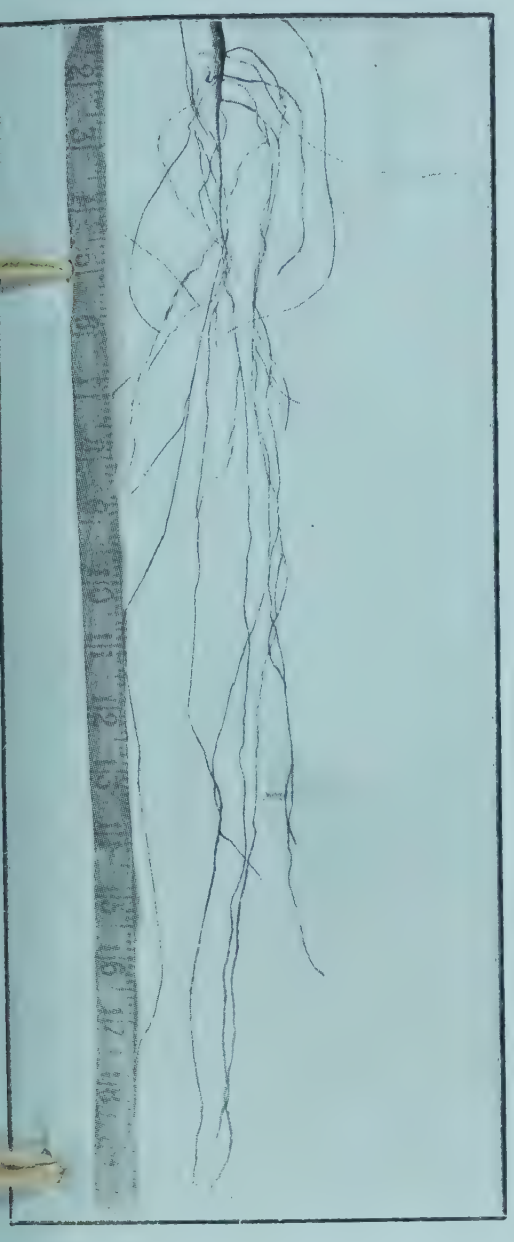


Root systems of Cawnpore-American (No. 14) and *desi* (No. 24) cotton plants, 66 days old; both sown on 3rd June.





Root systems of Cawnpore-American (No. 15) and *desi* (No. 26) cotton plants, 78 days old; both sown



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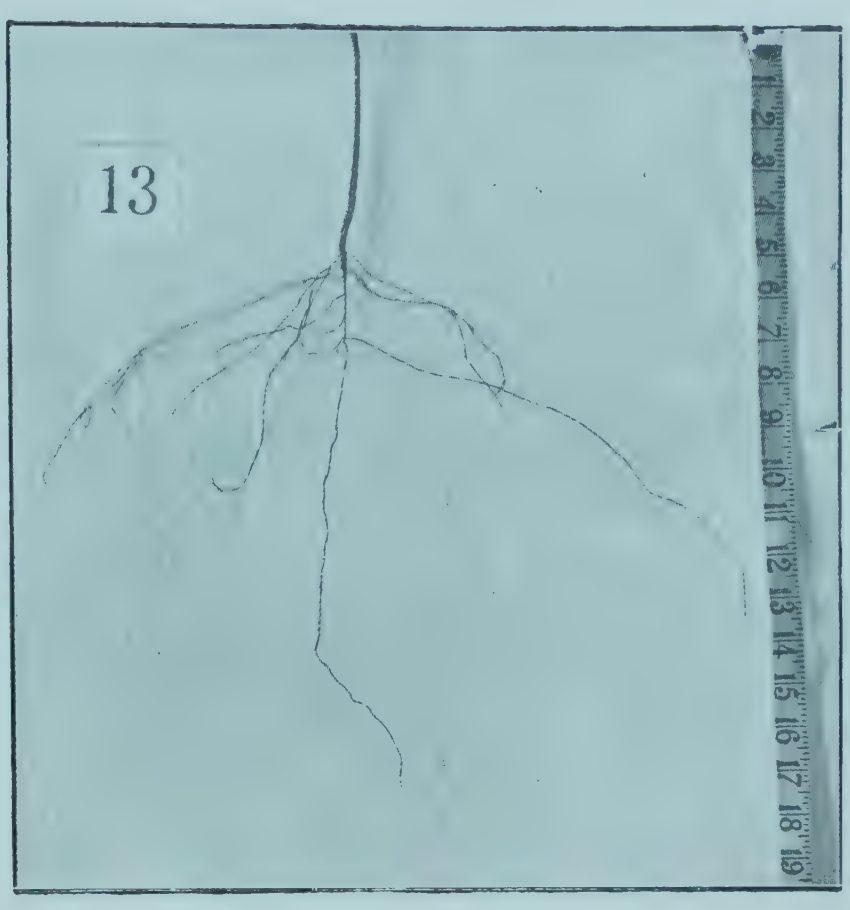

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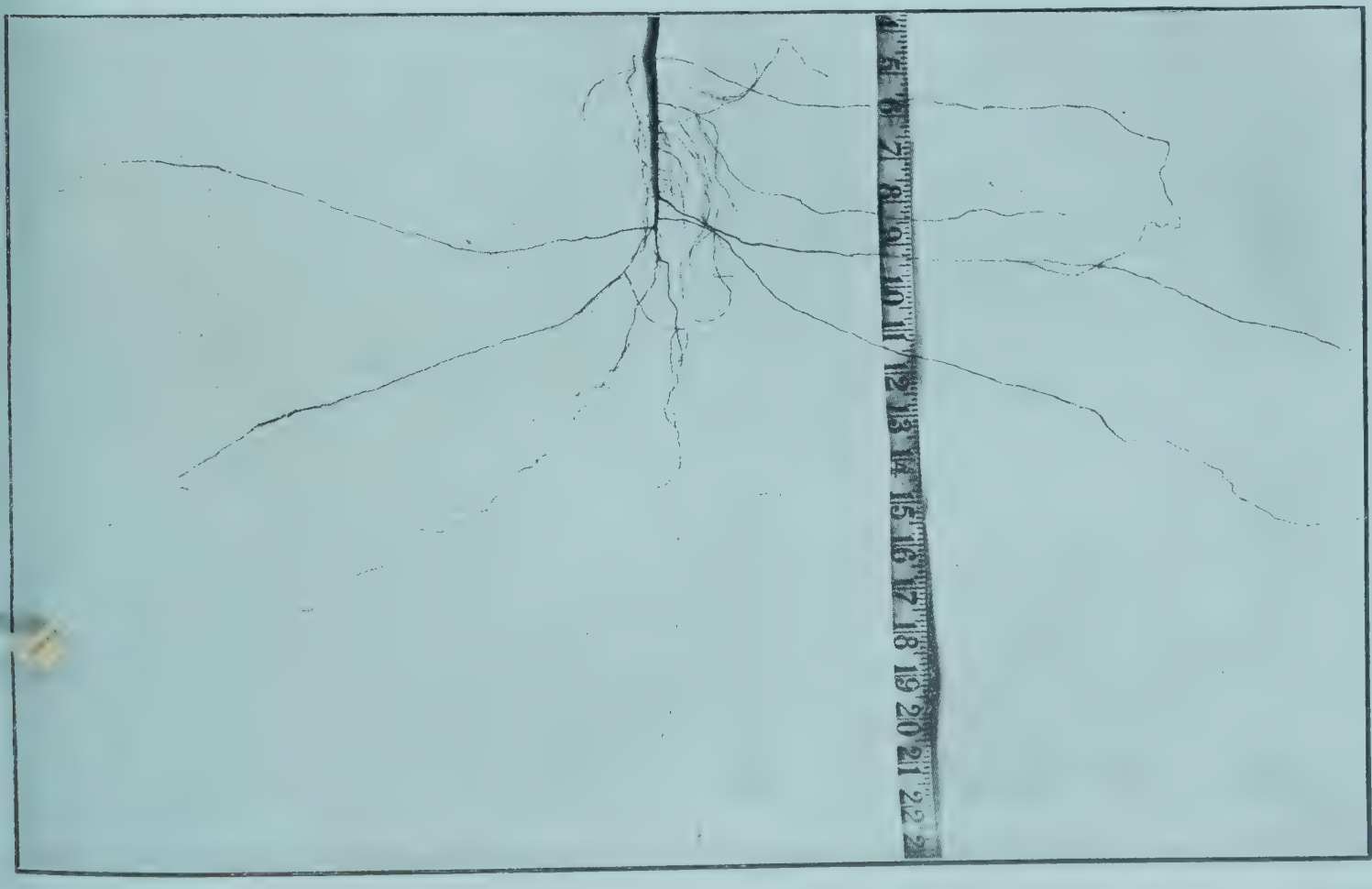
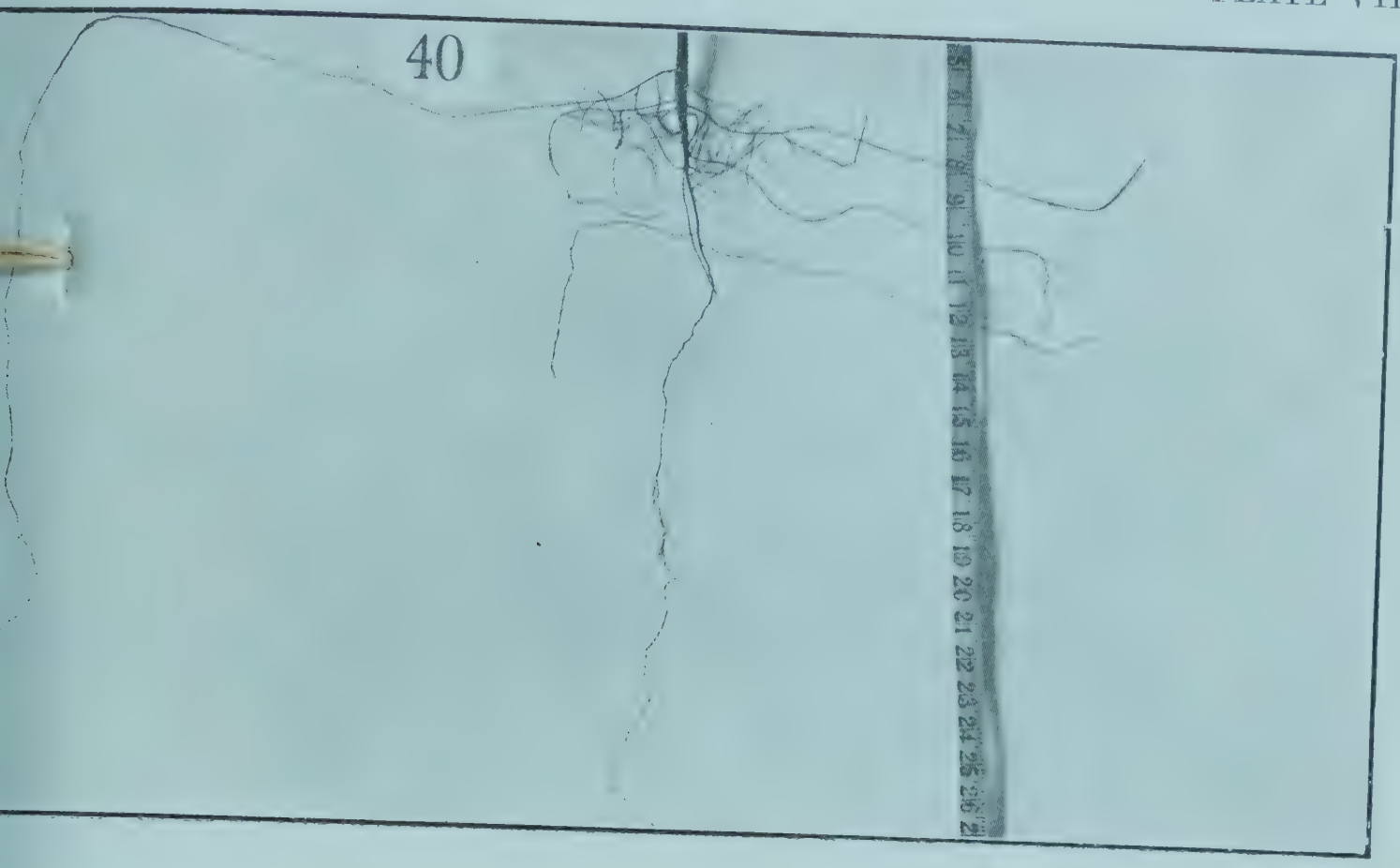
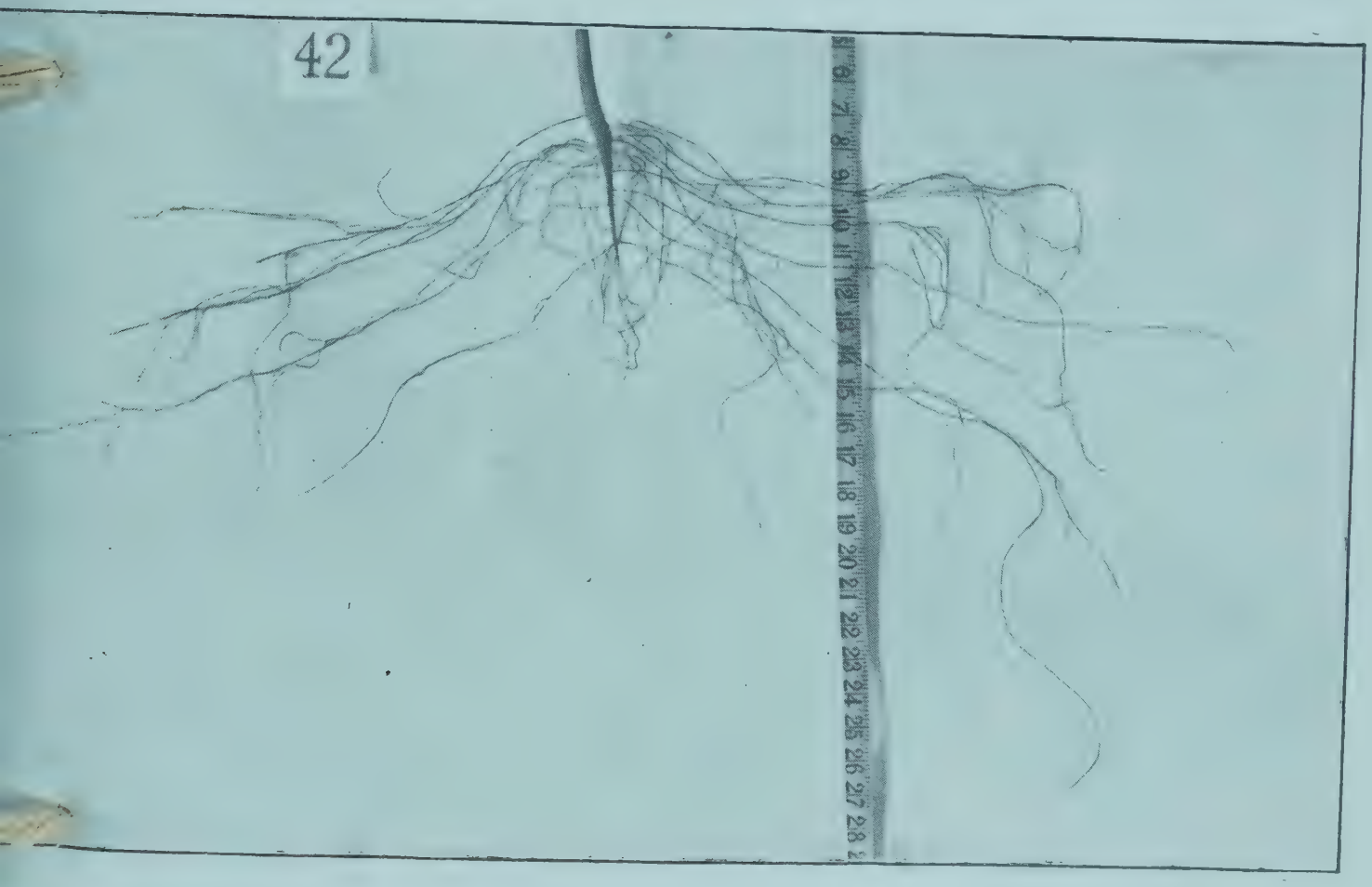
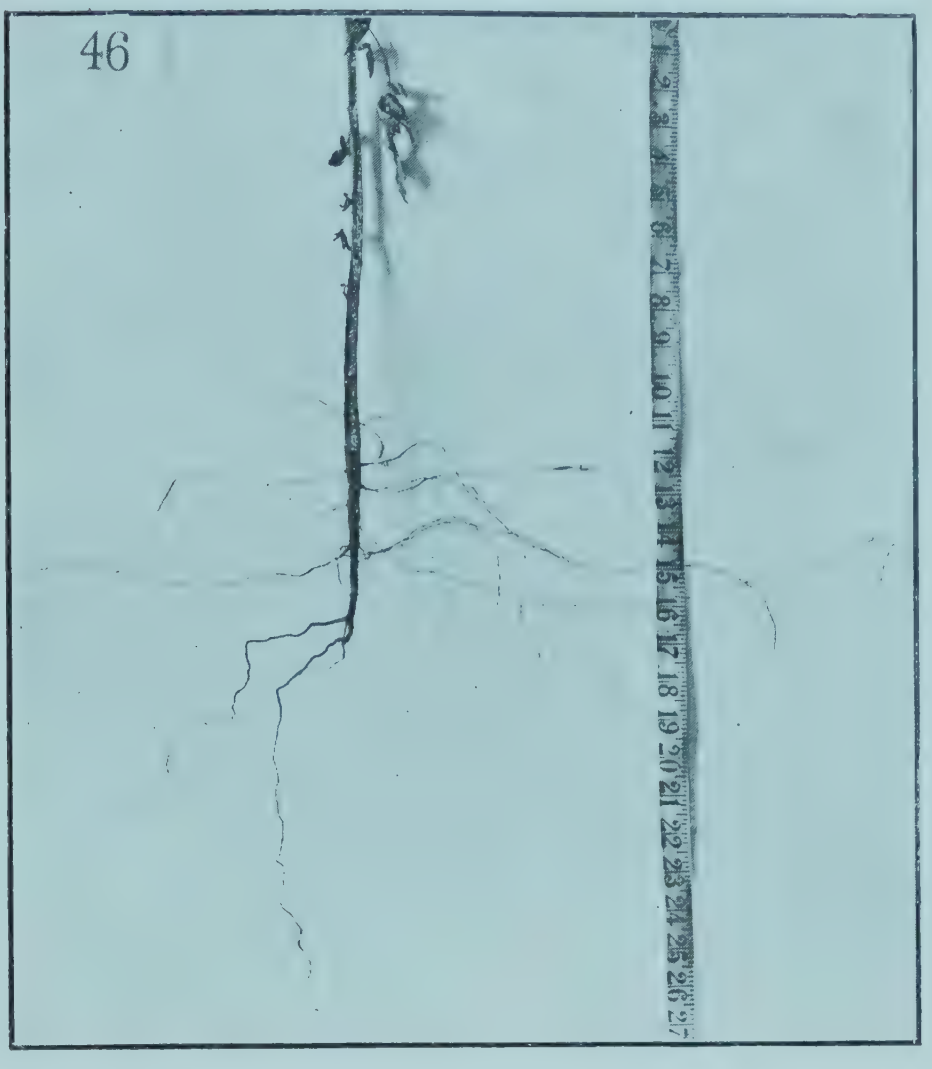


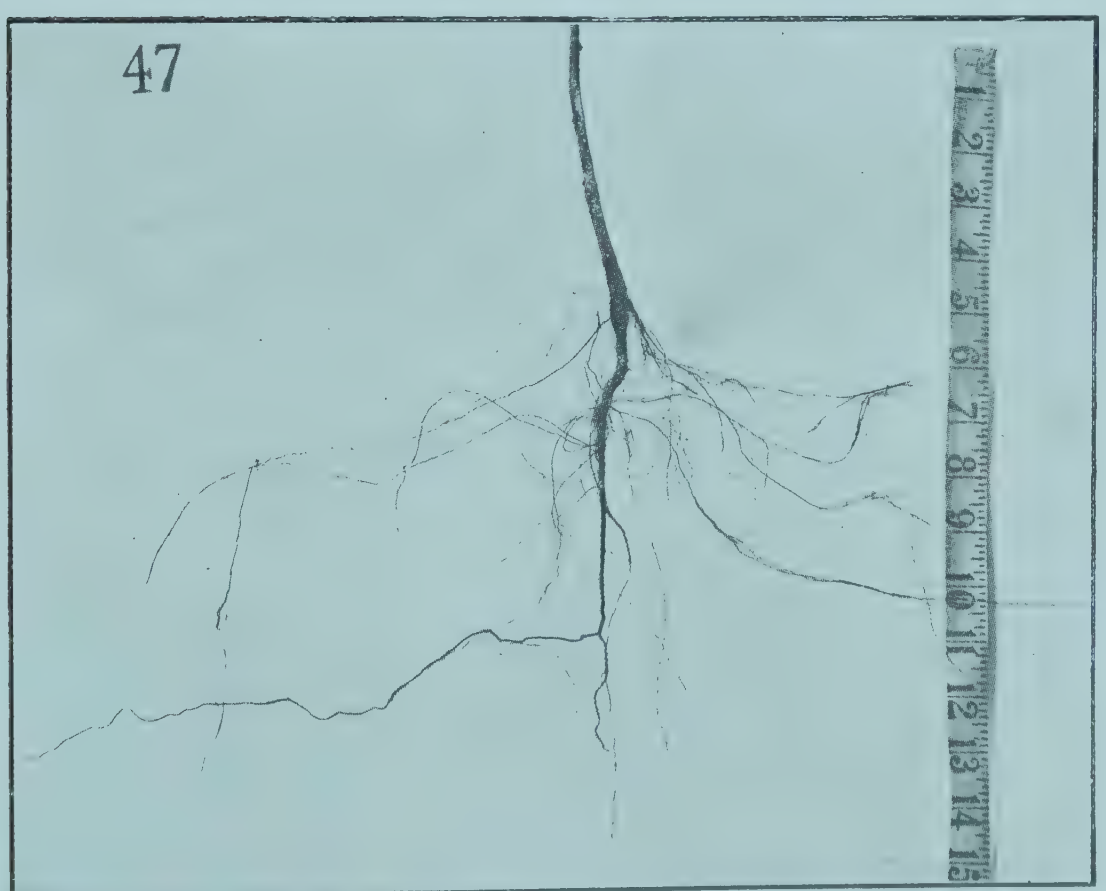
Root systems of Cawnpore-American (Nos. 6 and 13) and *desi* (No. 23) cotton plants. 67 days old; all sown on 15th June.



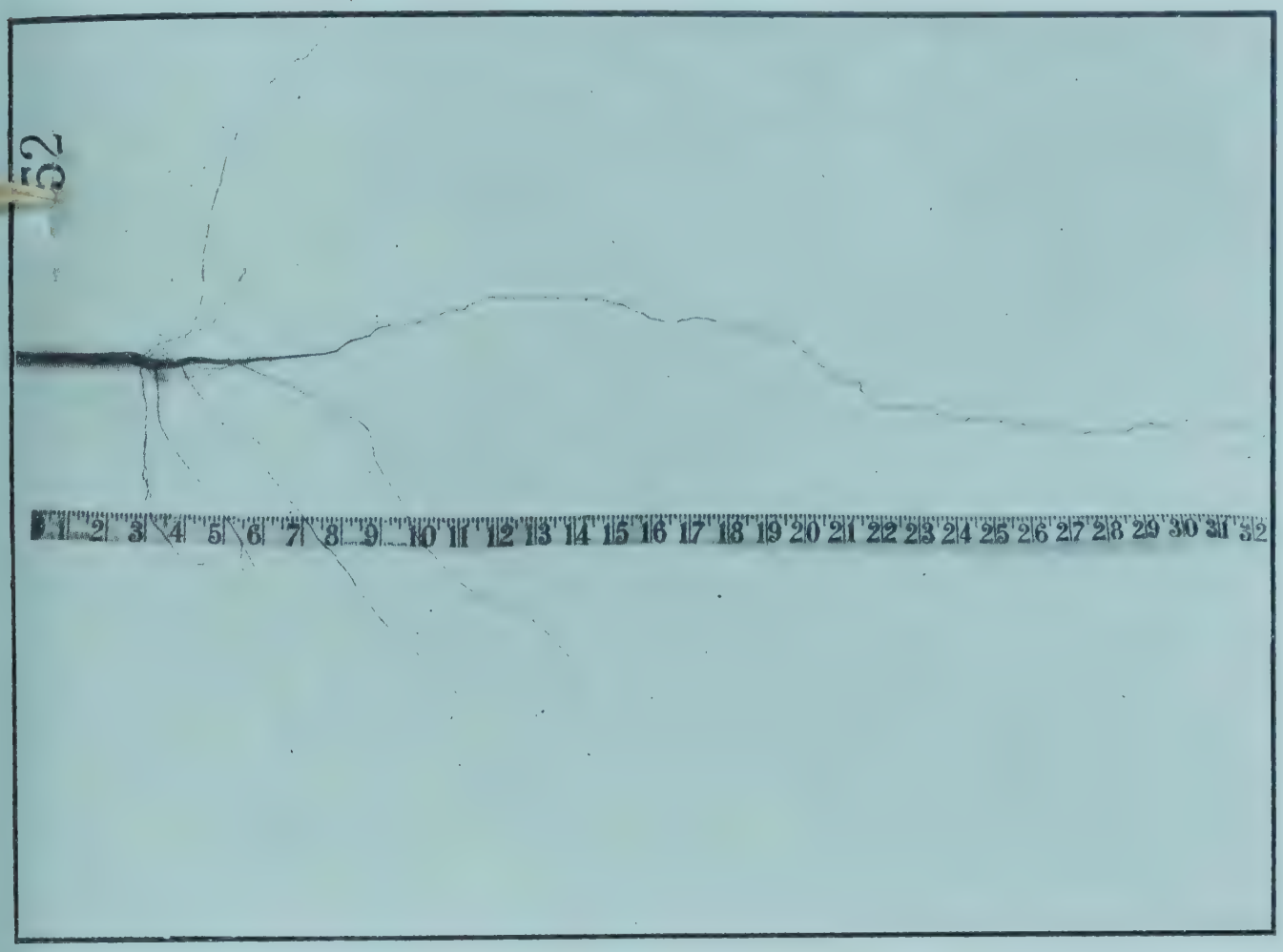


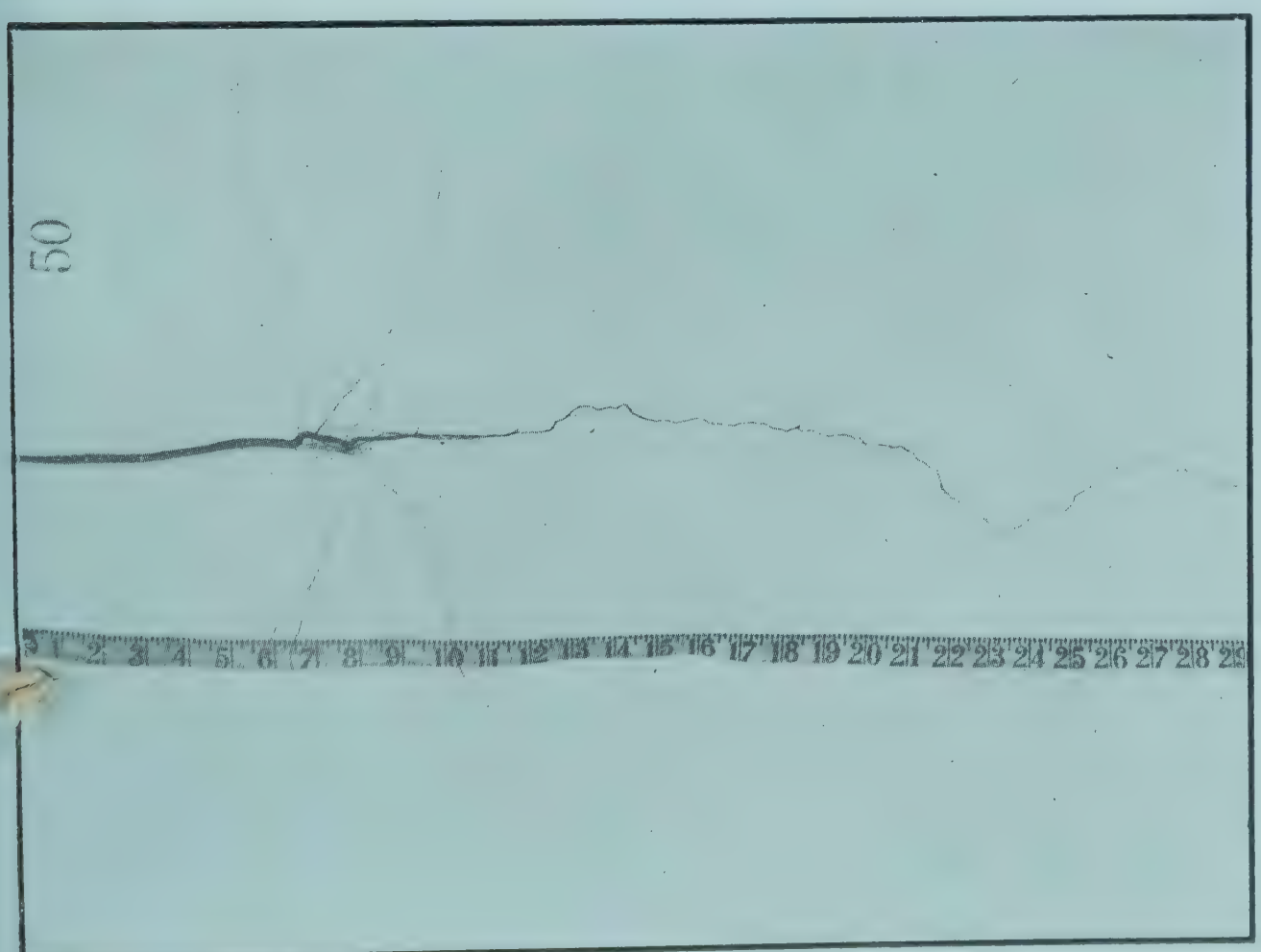
Root systems of Cawnpore-American cotton plants, 84 days old; both sown on 15th June.



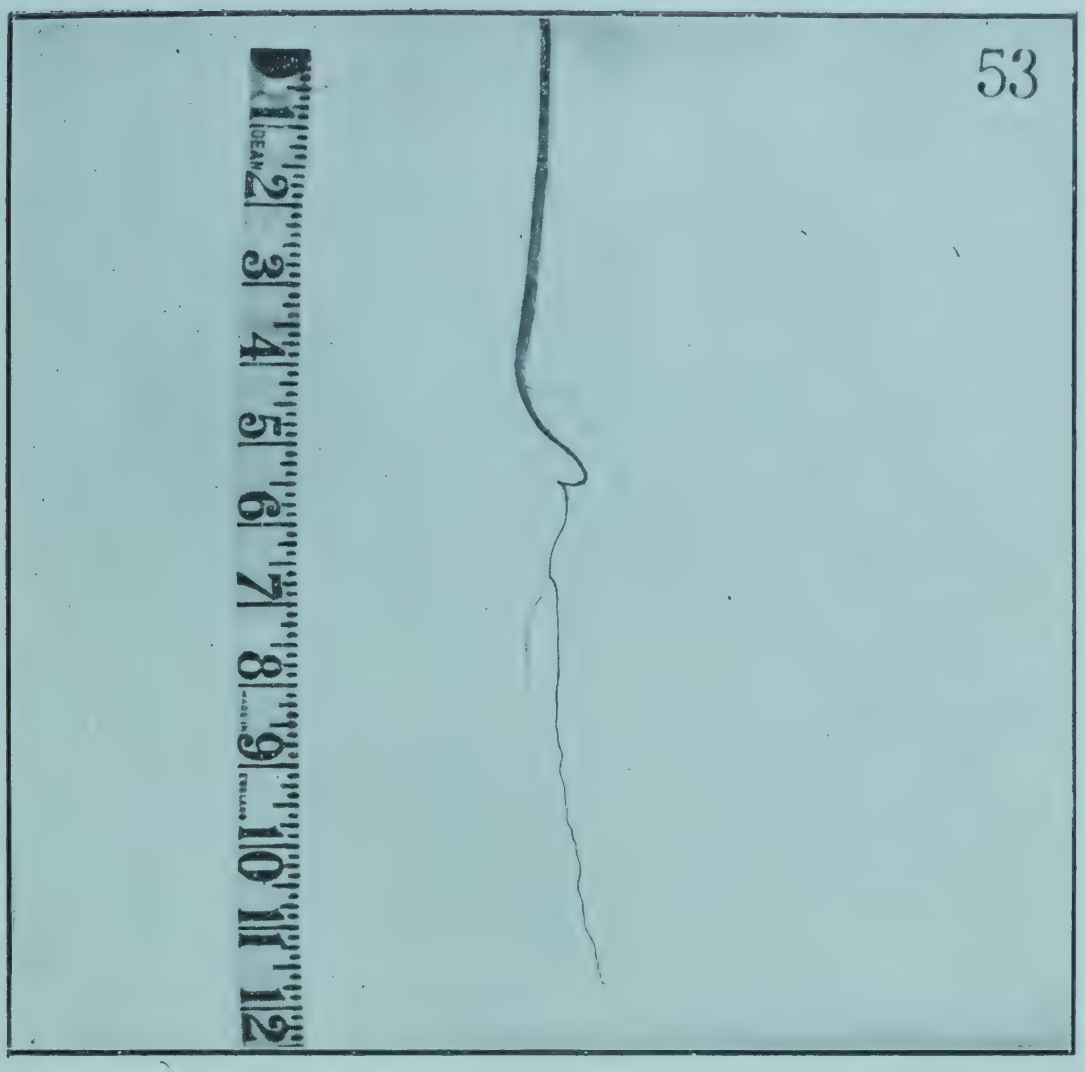


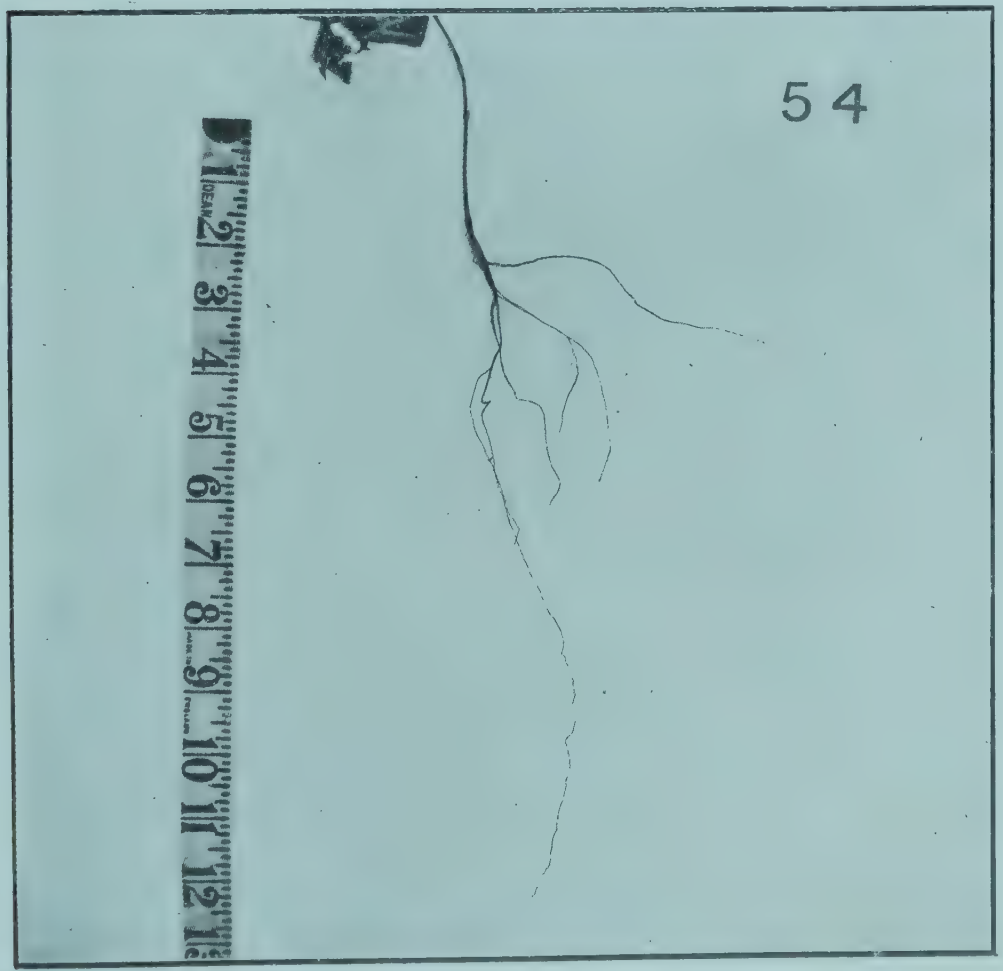
Root systems of *desi* cotton plants, 84 days old; both sown on 15th June.





Root systems of *desi* (No. 50) and Cawnpore-American (No. 52) cotton plants, 64 days old; both sown on 7th July.





Root systems of Cawnpore-American cotton plants, 64 days old; both sown on 7th July.

Second Hundred Notes on Indian Insects.

[*Received for publication on 5th December 1918.*]

101. Insect Pests of Tea in North-East India during the season 1916.

A noticeable feature of insect attack in the tea districts of North-East India during the season 1916 was, that while *Helopeltis theivora*, the tea mosquito, though severe, was not more than usually so, and in some cases less so, in districts which suffer from its depredations year after year, it appeared in increased numbers in districts which have usually been considered to be fairly free from attack. This happened, not in one isolated district, but in different and widely separated districts in the areas under tea, the three districts affected being the Eastern Duars, part of the Balisera district (to a less extent) and parts of the Sibsagar district (to a still less extent).

Another feature was the unusual severity of green fly attack in the Central Duars, following, in most cases, severe hail.

The Tea Mosquito.

(*Helopeltis theivora*, Waterh.)

Assam. This pest is reported from the North Bank of the river from the Bishnath district, where it appears to have been about the same as last year, with local fluctuations mostly for the worse. The pest was noticeable on the tea from the end of July or the beginning of August to the end of the season, though in one place it first appeared in June, and the attack was at its height in July and August. In the Mangaldhai district the tea mosquito is never a pest and the report from that district makes no mention of the insect. When the Entomologist was in that district in December, however, he noticed a patch of old tea, of about an acre in extent, in a garden close to the hills, which appeared to be suffering severely from mosquito blight. Investigation showed that the damage was not due to *Helopeltis*, but to the Capsid bug *Disphinctus humeralis*, and it is worthy of record that, while the attack was

extremely local, the bushes affected suffered serious damage identical in all respects with that caused by *Helopeltis*. Reports were not received from the North Lakhimpur or Tezpur districts.

On the South Bank of the river the tea mosquito was not mentioned as an active pest in the reports received, which were from the Lakhimpur and Jorhat districts, but during the season reports were received that it was becoming increasingly active in the Sonari district and in certain parts of the Jorhat district. In the Golaghat district the attack was similar to that in the previous year.

Cachar and Sylhet. In the Happy Valley this pest was worse than last year more especially in the east end of the district, while it was extremely bad in the Hailakandi district. In the Longai-Chargola district the damage, though serious and affecting some 50 per cent. of the total acreage, was hardly so bad as last year, and there was a tendency for the blight to lift in November. An important development in this area, however, was the increase in the damage done on certain gardens in the Balisera Valley.

Darjiling-Terai. The reports from these districts indicate that the severity of the attack was less than last year in the higher level gardens, but similar to last year in the lower level gardens.

Duars. In the Western Duars this pest appears to have held off a little longer than usual, but came down badly later in the season. In the districts further east, however, the attacks were much more severe than usual, and in the extreme eastern districts the pest appeared in sufficient numbers to make it evident that it has at last gained a foothold there, one or two gardens suffering severely.

Green Fly.

(*Empoasca flavescens*, Fab.)

Assam. On the North Bank green fly was again in evidence, being slight in some places, moderately serious in others, the worst months being June and July. There was less than usual in Upper Assam, while moderately bad attacks were experienced in parts of the Sibsagar district.

Cachar and Sylhet. No mention of green fly occurs in the reports from these districts.

Darjiling-Terai. In Darjiling attacks of green fly were slight, and less than last year. May and June were the worst months, but in some places the attack continued into August. This pest does not appear to have attracted attention in the Terai.

Duars. Green fly was particularly bad in the Nagrakata and Dina Toorea districts, following a hail, and reaching its climax in May and June. In other parts of this area the attacks were slight only.

Red Spider.

(*Tetranychus bioculatus*, W. M.)

Assam. Along the North Bank this pest was, on the whole, less serious than in the previous year, and the reports from districts on the South Bank indicate a similar state of affairs.

Cachar and Sylhet. No reports of serious attack, such as were experienced in some places during 1915, were received from these districts, and red spider, though general, appears not to have been particularly serious in the area as a whole.

Darjiling-Terai. In Darjiling this pest was not quite so serious as usual, and was worst in May. At the lower elevations of the Terai the pest was earlier in evidence, and at its worst in April-May, but does not appear to have been particularly serious.

Duars. Here the attack was much as usual, if anything less than last year. In many places, in addition to the usual attack in the early part of the season, the pest was also in evidence in October, November and December.

Red Slug.

(*Heterusia magnifica*, Butl.)

Assam. At one place in the Bishnath district this pest was serious during 1916, and persisted through the year, but at other places on the North Bank the damage done was negligible. No mention is made of its occurrence on the South Bank.

Cachar and Sylhet. There is no mention of the occurrence of the pest in these districts.

Darjiling-Terai. No mention of Red Slug.

Duars. Red Slug is again reported from the Chulsa district, but in even smaller numbers than last year.

Looper.

(*Biston suppressaria*, Guen.)

Assam. This pest is again reported from the North Bank only, but in much smaller numbers than in 1915. The autumn brood was again the one which did most damage.

Faggot and Bag Worms.

(*Clania* spp.)

Assam. Slight damage by these pests over restricted areas is reported from districts both on the North and South Banks.

Cachar and Sylhet. No damage reported.

Darjiling-Terai. No damage reported.

Duars. A slight occurrence of these pests is reported in the Chulsa district.

Nettle Grubs.

(*Thosea* spp.)

Assam. Local attacks of these pests occurred in parts of the Dibrugarh district, during the latter half of the season, and in one case the attack is reported as serious.

Cachar and Sylhet. No damage reported.

Darjiling-Terai. No damage reported.

Duars. In the Chulsa district a slight attack of these pests occurred in the early part of the season, the caterpillars being less in evidence than in 1915.

Thrips.

(*Physothrips setiventris*, Bagn., and an undescribed species.)

Darjiling. This pest was again serious in the Darjiling district, the attack being of normal intensity, though slightly less at some places and slightly worse at others. The insects were in evidence from April to October, and at their worst in May and June.

Crickets.

(*Brachytrypes achatinus*, Stoll.)

Assam. Damage by these insects in nurseries is reported from both banks of the Brahmaputra.

Termites.

(*Termes* (*Odontotermes*) sp.)

Sylhet. These pests are reported as serious in the Balisera Valley.

Other pests reported as having occurred are :—

"Borers" in the Duars.

Cluster Caterpillar (*Andraca bipunctata*, Wlk.) in the Jorhat district.

Tea Seed Bug (*Poecilocoris latus*, Dall.) in Bishnath and the Duars.

Carteria decorella, Mask., a scale insect received from the Chulsa district of the Duars.

(E. A. Andrews. *Qrly. Journ. Ind. Tea Assocn.*, Vol. VII, Pt. 3, pp. 75-79.)

102. Bothroponera rufipes.

The range of *Bothroponera rufipes*, Jerd., is given by Bingham (*F. I., Hym.*, II, 96-97, f. 50) as "Himalayas from the Siwaliks to Assam and up to 4,000 feet." When at Abbottabad, in the Hazara District of the N.-W. Frontier Province, in June 1916 I collected a single specimen, so that its distribution must be extended to the western extremity of the Himalayas. We also have specimens from Nepal, sent us by Col. Manners-Smith, V.C., when Resident there.

Bingham notes (*l. c.*) that this species when picked up or disturbed emits a thick white frothy liquid from their mouths with an overpowering smell of formic acid. The Abbottabad specimen, when caught in the forceps, was noted to emit a long mass of white frothy semi-liquid substance from the anal extremity, but no special smell was noticed.

Since writing the above note, I have also taken this species not uncommonly at Shillong, where it occurs singly under stones.

103. Parasites of Pseudagenia clypeata.

In *Entomological Memoirs*, Vol. IV, No. 4, page 195, mention was made of two parasites of the above-named wasp, but neither of them could be named at that time. They have now been identified as :—

(*i*) *Aphœbantus ceylonicus* (Bombylidæ).

(*ii*) *Gotra longicornis* (Ichneumonidæ; Cryptinæ).

The former has already been referred to in Note No. 47, under the name *Argyramœba ceylonica*.

Gotra longicornis has since been bred from the cells of *Pseudagenia blanda* also.

104. A parasite of Athalia proxima.

In the *Memoirs of the Department of Agriculture in India* (*Entomological Series*), Vol. I, page 369, it is mentioned that two species of Ichneumon flies parasitize the larvæ of the Mustard Sawfly (*Athalia proxima*, Kl.). One of these parasites is shown on Plate XX, figure 10, and this is described by Mr. Morley (*Fauna of India, Hymenoptera*, Vol III, page 331) as *Exacrodus populans*.

105. Hosts of some Indian Ichneumonidae.

This list includes only such species as have actually been bred from known hosts and are represented in the Pusa Collection.

PIMPLINÆ.

(1) *Xanthopimpla immaculata*, Morl.

Bred from—

(*a*) *Cnaphalacrocis medinalis*, Guen. (*Pyralidæ*), Dacca.

(*b*) *Telicota augias*, Linn. (*Hesperiadæ*), Palur, Madras.

In the collection specimens are from the following localities also :— Bihar, Chapra; Central Provinces, Jubbalpore; South India, Coimbatore.

(2) *Xanthopimpla punctata*, Fb.

‖*ceylonica*, Cam.

Bred from—

(*a*) *Chilo simplex*, Butl. (*Pyralidæ*), Punjab, Lahore.

(*b*) „ „ „ Central Provinces, Betul.

(*c*) *Sphenoptera gossypii* (*Buprestidæ*) Central Provinces, Nagpur.

In the collection specimens are from the following localities also :— Bihar, Pusa and Chapra; Central Provinces, Bilaspur and Raipur; Bombay, Surat.

(3) *Xanthopimpla nursei*, Cam.

Bred from—

(*a*) *Chilo simplex*, Butl. (*Pyralidæ*), Central Provinces, Nagpur.

(*b*) „ „ „ Bihar, Pusa.

(*c*) *Scirpophaga auriflua*, Z. „ „ Champaran.

(*d*) *Plusia* sp. (*Noctuidæ*), Bombay, Belgaum.

In the collection specimens are from the following localities also :— Bihar, Chapra; Nilgiris, Naduvatam; Bombay, Surat.

OPHIONINÆ.

(4) *Henicospilus merdarius*, Grav.

Bred from *Euproctis scintillans*, Wlk. (*Lymantriadæ*), Madras, Saidapet.

In the collection specimens are from the following localities also :— Bihar, Pusa and Chapra; Central Provinces, Balaghat, Nagpur and Hoshangabad; Bombay, Nadiad; Madras, Penukonda.

(5) *Henicospilus atricornis*, Morl.
Bred from *Sylepta derogata*, Fb. (*Pyralidæ*), Central Provinces, Balaghat and Nagpur.

(6) *Charops erythrogaster*, Ashm.
Bred from—

Achæa janata, Linn. } (*Noctuidæ*) Bihar, Pusa.
‖*melicerta*, Dr. }

(7) *Dioctes argenteopilosa*, Cam.
Bred from—

Laphygma exigua, Gn. } (*Noctuidæ*) Central Provinces, Nagpur.
‖*Caradrina exigua*, Gn. }

(8) *Dioctes debilis*, Morl.
Bred from—

(*a*) *Sphenarches caffer*, Zell. (*Pterophoridæ*), Central Provinces, Nagpur.
(*b*) *Exelastis atomosa*, Wlsm. (*Pterophoridæ*), Bombay, Surat.

(9) *Dioctes albicalcar*, Morl.
Bred from *Catochrysops cnejus* (*Lycænidæ*), Bihar, Pusa.

(10) *Angitia fenestralis*, Holmg.
Bred from *Plutella maculipennis*, Curt. (*Plutellidæ*) Punjab, Lyallpur.

(11) *Tarytia flavo-orbitalis*, Cam.
Bred from—

(*a*) *Antigastra catalaunalis*, Dup. (*Pyralidæ*) Bihar, Pusa.
(*b*) *Chilo simplex*, Butl. ,, ,, ,,
(*c*) *Euzophera perticella*, Rag. ,, ,, ,,
(*d*) *Argyroploce paragramma*, Meyr. (*Eucosmidæ*) ,,

(12) *Pristomerus testaceus*, Morl.
Bred from—

(*a*) *Leucinodes orbonalis*, Gn. (*Pyralidæ*), Central Provinces, Nagpur.
(*b*) ,, ,, ,, Bihar, Pusa.
(*c*) *Euzophera perticella*, Rag. ,, Madras, Attur.

In the collection specimens are also from Bihar, Chapra.

(13) *Edrisa pilicornis*, Cam.
Bred from the cocoons of a Microgasterid parasite of *Achæa janata*, Linn., Bihar, Pusa.

CRYPTINÆ.

(14) *Melcha ornatipennis*, Cam.

Bred from *Scirpophaga auriflua*, Zell. (*Pyralidæ*), Bihar, Pusa.

In the collection specimens are also from Bihar, Chapra.

(15) *Gotra longicornis*, Cam.

Bred from—

(*i*) *Pseudagenia blanda*, Guèr.
(*ii*) „ *clypeata*, Bingh. } (*Pompilidæ*).

(16) *Melcha nursei*, Cam.

Bred from—

(*a*) *Earias fabia*, Stoll. (*Noctuidæ*), Bihar, Pusa.

(*b*) *Plusia orichalcea*, Fb. (*Noctuidæ*), United Provinces, Cawnpore.

ICHNEUMONINÆ.

(17) *Aglaojoppa alecto*, Morl.

Bred from *Parnara mathias*, Fb. (*Hesperiadæ*) Bihar, Pusa.

In the collection specimens are also from Bihar, Chapra.

(18) *Ischnojoppa luteolator*, Fb.

Bred from *Schænobius bipunctifer*, Wlk. (*Pyralidæ*), Madras, Coimbatore.

In the collection specimens are from the following localities also :—

Bihar, Pusa and Chapra; Bombay, Bassein Fort; Madras, Samalkota.

G. R. DUTT.

106. Edrisa pilicornis.

Edrisa pilicornis, Cam. (Morley, *Fauna of India, Hym.*, Vol. III, p. 521) was originally described by Cameron in *Tijds. Ent.* (1907), p. 112, from specimens collected by Colonel Bingham in Sikkim. In 1912 this species was in evidence at Pusa in castor plots where the plants were badly attacked by the caterpillars of *Achæa janata*, Dr. Later on in the season a number of *Achæa* caterpillars were found to be parasitized by a *Microgasterid* parasite which is figured in the *Memoirs of the Department of Agriculture in India* (*Entl. Series*), Vol. II, No. 4, p. 73, pl. 7, f. 7, but has not yet been identified. While rearing the cocoons of this parasite a number of individuals, male and female, of *Edrisa pilicornis* were noticed inside the cage. Further observations established the fact that *Edrisa pilicornis* is a parasite of the *Microgasterid*, which

Fig. 1. *Edrisa pilicornis*, natural size, and magnified × 16.

Fig. 2. *Spinaria leucomelæna*, natural size, and magnified × 6.
On right is more highly enlarged view of base of antenna.

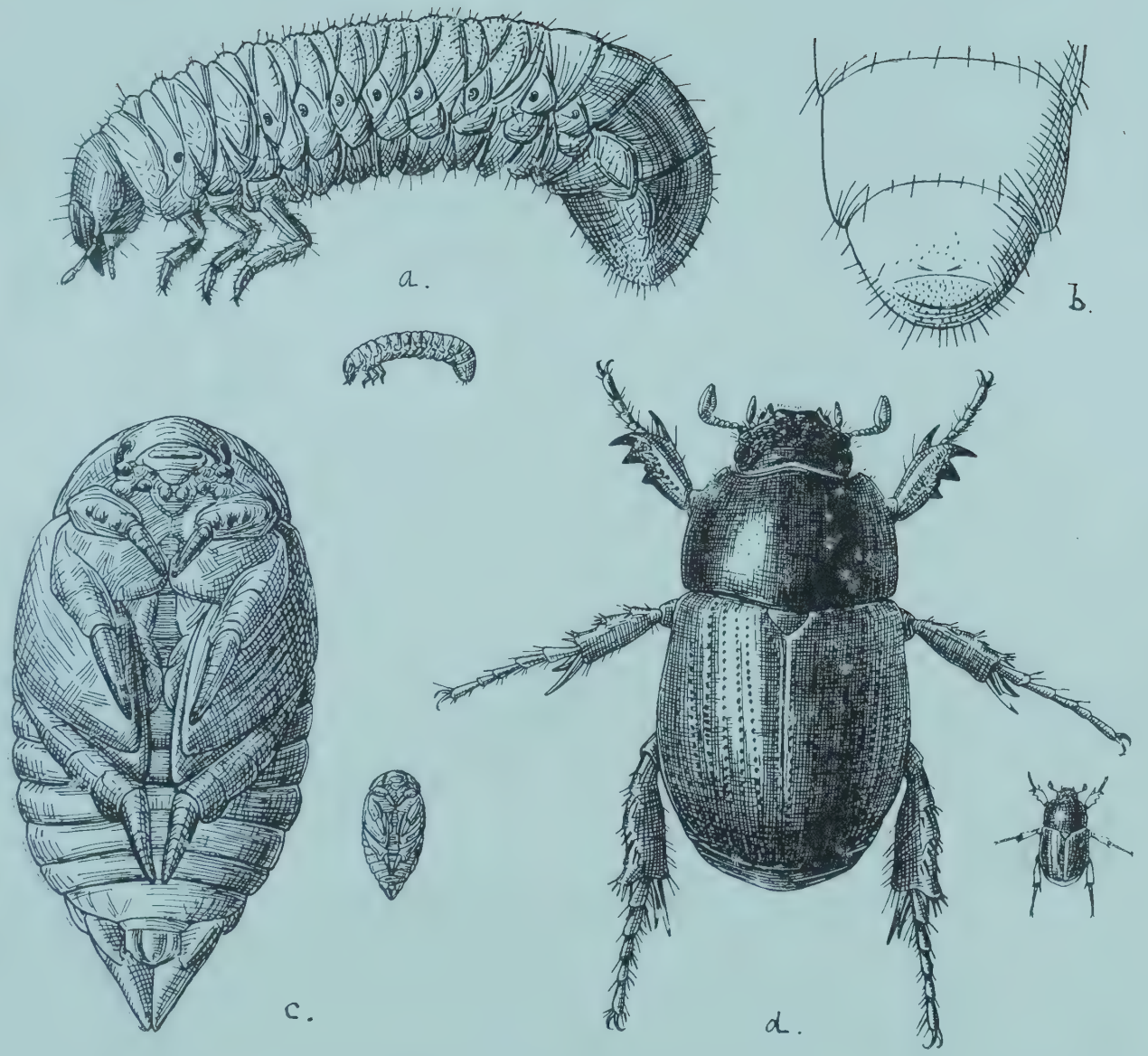


Fig. 3. *Alissonotum piceum.*
a, Larva, natural size, and enlarged (× 4½).
b, Posterior extremity of larva, ventral view, more highly magnified.
c, Pupa, natural size, and enlarged (× 4½).
d, Imago " " " "

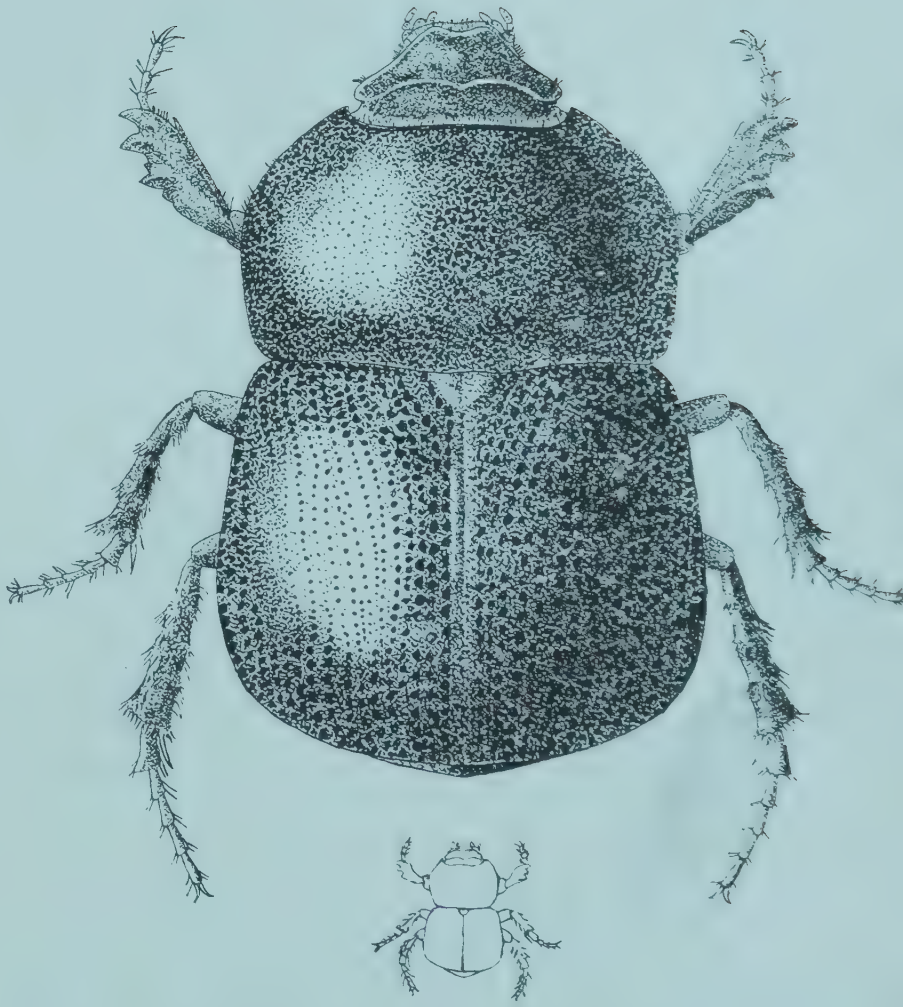


Fig. 4. *Pentodon bengalense* (× 6).
The small outline figure shows the natural size.

is in turn parasitic on the caterpillars of *Achæa janata*. When counts were made it was found that the *Microgasterid* cocoons were heavily parasitized, as many as 72 per cent. of the cocoons yielding *Edrisa*.

G. R. Dutt.

107. Spinaria leucomelaena in Southern India.

During a tour in Coorg in November 1915 two specimens of a species of *Spinaria* were captured at Pollibetta, and these have been identified as *Spinaria leucomelæna*, Westwood [*Tijds. voor Ent.*, XXV, 31, t. 7, f. 2, (1882)], originally described from Siam and not previously recorded from the Indian Region. *Spinaria nigriceps*, Cam. [*Manch. Mem.*, XLI, No. 4, pp. 37-38, t. 3, f. 7 (1897)] was described from Ceylon, but this is readily separated from *leucomelæna* by the black thorax of the latter species. Nothing seems to be known regarding the habits of these curious Braconids.

108. Oxycetonia jucunda in the Palni Hills.

Oxycetonia jucunda is recorded in the Fauna volume (pp. 168-170, ff. 37, 38) from the Himalayan Hill Region, ranging thence to Siberia and Japan. Three specimens taken at Kodaikanal at an elevation of 6,000 feet in the Palni Hills in 1913 (L. V. Newton coll.) have been identified by Mr. Arrow as this species, whose range is thus extended into Southern India. Of the three specimens, one is green, the second is red, and the third belongs to Arrow's variety *a*.

109. Early stages of Alissonotum piceum.

A larva of *Alissonotum piceum* was found at Pusa on 14th May 1917 gnawing into the base of a sugarcane shoot in the field. The shoot showed a "dead-heart" and, on turning over the earth, the larva was found eating into it in the same way as *Gryllotalpa* does. In confinement it bored into a thick piece of cane sett, throwing out dust in the manner of wood-borers. The larva pupated on 25th May and the adult beetle emerged on 3rd June 1917.

Pusa Insectary (Cage-slip 1578).

110. Pentodon bengalense as a cane-pest.

In May 1912 specimens of *Pentodon bengalense*, Arr., were received from Peshawar with a report that they had been found attacking newly-

sprouted sugarcane shoots over an area of eight acres. The accompanying report from the Agricultural Officer, North-West Frontier Province, stated that "the beetle begins tunnelling at the soil surface, about two or three inches distant from the shoot; the tunnel goes to the base of the shoot, where the beetle is usually found nestling beside the injured shoot, or the beetle is frequently found inside the injured shoot which shows a dead-heart, whose base is eaten quite through. Close by each old injured shoot two holes are generally found on the soil surface and it is thought that one of the holes serves for ingress and the other for egress. A pair of the beetles were found coupling near the base of the shoot."

P. bengalense was described by Arrow (*Fauna of India, Dynastinæ*, p. 304, f. 71) from Pusa and Rajmahal, but is probably widely distributed throughout Northern India. Except at Peshawar it has not been noted as a pest. It has been reared at Pusa from larvæ found eating cane shoots in May 1906 and 1909. The larva is about 20 mm. long and 5 mm. broad, flattened, dorsally convex, middle of body narrower than thoracic region, posterior portion of abdomen thicker, almost cylindrical, yellowish-white; head brownish yellow or red-brown.

A larva collected on 20th May 1906 pupated on 24th June and emerged on 3rd July 1906. Another larva, collected on 1st May 1909, pupated on 2nd July and emerged on 12th July 1909.

Pusa Insectary (Cage-slips 357, 768).

111. Anomala bengalensis attacking sugarcane.

Note No. 12 dealt with some larvæ of *Anomala bengalensis* found breeding in leaf-mould at Pusa. In July 1917 larvæ of this beetle were found, both at Pusa and Dacca, underground near roots of sugarcane gnawing into the growing stem from the side and causing the plants to wither. In confinement these larvæ were reared on pieces of sugarcane stem, which were gnawed into from the side. The larva passes the winter in the larval state and pupates about the end of March, the adult beetles emerging in the middle of April. The accompanying figures of larva and imago were drawn from the Dacca specimens referred to above.

Pusa Insectary (Cage-slip 1779).

112. Early stages of Aphodius moestus.

The early stages of *Aphodius mœstus* are passed in cattle-dung, either on the ground or collected in the form of cakes for purposes of fuel. So long as the interior of these cakes remains moist, the larvæ are able to live in them. When the dung is lying on the ground, the

Fig. 5. *Anomala bengalensis.*

a, Larva (× 3).
b, Posterior segment of larva, ventral view, more highly magnified.
c, Imago (× 3).

Fig. 6. *Aphodius moestus.*
a, Larva, natural size, and magnified (× 10).
b, Pupa, „ „ „ „
c, Imago, „ „ „ „

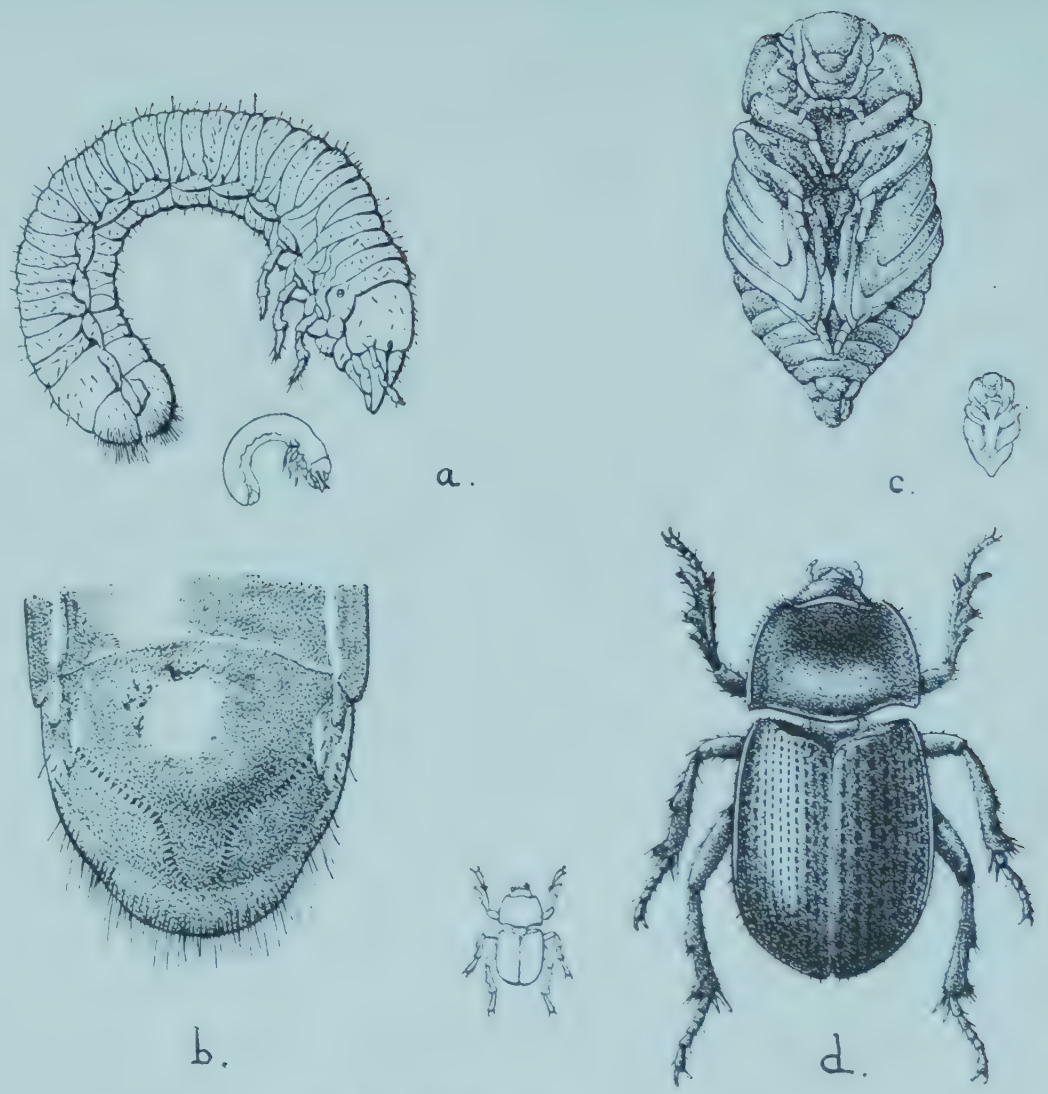


Fig. 7. *Hybossorus orientalis.*
a, Larva (× 4).
b, Under surface of anal segment showing arrangement of spinous hairs.
c, Pupa (× 4).
d, Adult (× 4).
The small outline figures show natural sizes.

larvæ, when full-fed, go down into the soil, excavate an oval space, and pupate there; but in the case of cakes applied to walls, etc., or when the soil is unsuitable, pupation takes place in chambers made in the dung. The life-cycle is short, probably about or less than three weeks.

The full-grown larva is about 8 mm. long and about 2 mm. broad across the anterior and 2·5 mm. across the posterior portion of the body. In general appearance it is much like a young *Anomala* larva and is ventrally incurved, convex dorsally and rather flattened ventrally. Head rounded, dark brown, shining. Three pairs of well-developed pale-yellow legs. No distinct shield on prothorax but a yellow marking present on either side of pronotum. Body much wrinkled, white or pale yellowish-white, the dorsal vessel and visceral contents plainly visible.

The pupa is about 6 mm. long and 3 mm. broad across the wing-covers, ventrally incurved, uniform brownish-yellow, with a pair of long tapering divergent spines on the anal segment. The pupal period is four or five days.

Pusa Insectary (Cage-slips 844, 1545).

113. Early stages of Hybossorus orientalis.

On 6th July 1914 a pupa of *Hybossorus orientalis*, Westw., was found in farmyard manure at Pusa and emerged as an adult on 12th July. On 28th July 1916 three larvæ were similarly found and five more on the following day, and on 15th August 1916 larvæ were also found in cattle droppings on roads and in the pasture areas. The adult beetles emerged between 18th August and 11th September, the pupal period being ten or twelve days.

The full-grown larva is about 20 mm. in extreme length, stoutest across the metathoracic region which is about 5 mm. broad, and tapering slightly anteriorly and more pronouncedly posteriorly, the hinder extremity being about 3 mm. broad. It is of the ordinary Scarabæid form. Head smooth, shining yellow-brown. Body uniformly pale yellow and with a delicate appearance in comparison with such larvæ as those of *Anomala*. Segments subdivided, the subsegments bearing short brown hairs. Anal segment with a transverse indentation and with longish brown hairs on dorsal and posterior areas, ventrally with an obliquely curved row of short spinous hairs, as indicated in figure 7, arising from the anterior margin and reaching median portion of the posterior fold. The spiracles differ from those of *Anomala* and similar larvæ, being unicolorous with the body and scarcely distinguishable. Tarsi of all three pairs of legs well-developed, spinous.

When placed on a flat surface the larva does not walk on its ventral surface, or on its dorsal surface (like *Protætia* larvæ), but it progresses somewhat obliquely on one side. When disturbed it coils up and, unlike other Scarabæid grubs, the anal extremity is raised over and overlaps the body to some extent.

Pusa Insectary (Cage-slips 1071, 1436).

114. Sthenias grisator.

This beetle was found in rather large numbers at Coimbatore in December 1914 damaging mulberry bushes at the Insectary. Many of the stouter twigs were found to have been deeply girdled all round by these beetles, a little above the base. The girdle ultimately became so deep that the twigs broke at the part attacked and fell to the ground. A careful examination of the twigs revealed the presence of numerous little cuts in the bark made by the beetles. A slight prominence may be noticed in the bark either above or below the slit. This is caused by the presence of an egg thrust in between the bark and the wood by the female beetle. The egg is somewhat cigar-shaped, more pointed towards one end than the other, dull white and very slightly flattened. The grub hatches in about 9 days, and begins at once to bore into the wood of the twig. The grub tunnels into the woody tissue and feeds on it till the twig is reduced to a mass of yellow dust and excreta, wrapped up by the thin cover of the bark. In some places the grub thrusts out through slits in the bark some of the yellow dust and grass which may be found in small heaps on the ground.

The grub when full grown is about 1 inch long. It prepares an elongate chamber in a part of its tunnel and pupates.

The pupal period has not been definitely determined.

The length of its life-history seems to vary a good deal. From larvæ hatching from eggs in January-February 1915 a few beetles emerged in May 1915, some in August-October 1915, and a few in January-March 1916. Some are yet in the larval stage. This is probably due to adverse conditions under confinement. In nature the length of the cycle would be about 4 or 5 months.

Nerium odorum, Bongainvillea, Moringa, etc., were also attacked.

Y. Ramachandra Rao.

115. Identification of Soy-bean Stem-borer.

The longicorn beetle boring in stems of soy-bean in Bihar, whose life-history has been described by H. L. Dutt in the *Bihar Agricultural*

Journal (Vol. III, pp. 52-56, April 1915), has now been identified as *Nupserha bicolor*, Thoms., and this name should be used in any further references. The insect is known to occur in Northern India and Java.

116. A new Weevil Pest from Kulu.

Under date of 5th July 1914 a correspondent at Chawai, Kulu, in the Kangra District of the Punjab forwarded specimens of a weevil which had attacked his orchard, completely defoliating the trees. He wrote :— "The insects first of all appeared on an alder tree (*Alnus nitida*) in a zamindar's field adjoining my orchard. After completely defoliating the alder, they attacked peach trees in my orchard. When they had completely eaten away the peaches, they began to attack the apricots and pears. Apples were the last to be touched."

Specimens of the weevil were forwarded to Dr. G. A. K. Marshall, who writes that it represents a new genus and species, which he has called *Emperorrhinus defoliator* and described in *Bull. Ent. Res.*, VI, pp. 366-368, f. 1. (February 1916).

This species also occurs at Kurseong and Darjiling and in the Khasi Hills.

117. An attack on fruit-trees by Emperorrhinus defoliator in Kulu.

Lala Guran Ditta Mal, Forest Ranger, Chawai, Kulu, Kangra District, under date of 23rd July 1917, has given us an interesting account of the occurrence of *Emperorrhinus defoliator*, Mshll., in Kulu in 1917. He writes as follows :—

"Great efforts were made to find out the winter hiding places of the weevils but with no success. So as a precautionary measure all the dry grass in the orchard was burnt down during the month of December 1916. But this did not do any good. On careful observation it was found out that the weevil first of all appeared at the bottom of the valley and slowly but steadily worked its way upwards towards the orchard, defoliating each and every wild pear tree in the way. In addition to the wild pear trees, all other broad-leaved trees and shrubs with soft leaves were eaten away.

"Thus the weevil approached the orchard in the beginning of July 1917, where we were ready to meet it. Spraying with strong doses of lead arsenate was continuously done every morning, using 1 oz. for every 4 gallons. In addition to this, the insects were not allowed to rest at leisure, but were continually disturbed by shaking the trees. In the

night time they were driven off with torches and as soon as they fell down in the pits they were crushed to death with broad wooden sticks. All the shrubs in the vicinity were also cut down and burnt so as not to give them any resting place.

"By 10th July the attack had spread on to seven pear trees. But then it suddenly stopped and the insects began to decrease, until by 20th they had disappeared altogether, only eating away half the leaves of seven pear trees.

"Now the weevils are going up the valley, defoliating each and every wild pear tree which comes in their way. It was noticed that when once the weevils went up, they never came down.

"Although the spraying with lead arsenate was a great check, yet continuous disturbing and burning with torches contributed a great deal in suppressing the pest. They came to know that that orchard was not a safe place for them and thus retreated in grief.

"Another peculiar practice of this pest is that it is only a local pest. It is found only in a limited area about two miles square. A private orchard situated at a distance of about 2½ furlongs from our orchard is not visited at all by the pest. Our orchard appears to be the northern boundary of its area of operation."

118. Early stages of Myllocerus discolor.

Myllocerus discolor, Boh., has been reared on several occasions at Pusa from larvæ and pupæ found underground at roots of maize, sugarcane, and of a wild *Amaranthus*. The larvæ seem to feed on the roots and do a small amount of damage.

The full-grown larva is about 7 mm. long and 3 mm. broad across the thoracic region, whence the body tapers posteriorly, dirty white; head brownish yellow, narrower than prothorax.

Pupation takes place underground with a specially prepared cell. Pupa about 6 mm. long, dirty white. The pupal period is about three weeks.

This weevil has been described and figured in *Fauna of India, Curculionidæ*, Vol. I, pp. 348-350, f. 106, where a list of foodplants of the adult beetle is also given. In the *Planters' Chronicle*, Vol. V, p. 273 (June 1910), this species (presumably var. *variegatus*, Boh.) is stated to do a good deal of damage to the foliage of fruit-trees in the neighbourhood of Ootacamund in January and February, just at the time when the trees are breaking into new leaf.

Pusa Insectary (Cage-slips 356, 1095 and 1622).

Fig. 8. *Mylloceras discolor.*
a, Larva, natural size, and magnified (×8).
b, Pupa „ „ „ „
c, Imago „ „ „ „

Fig. 9. *Apoderus tranquebaricus* (×12).

Fig. 10. Mango leaves twisted by *Apoderus tranquebaricus*.

119. Apoderus tranquebaricus as a pest of Mango.

Apoderus tranquebaricus, Fb., is commonly observed as a leaf twister of the common country almond tree (*Terminalia catappa*) in South India. Occasionally however it has been noted on mango. Last December while at Chittoor in connection with the mango hopper spraying campaign I came across this weevil in rather large numbers on mango trees. At this season of the year several trees put out fresh shoots and tender leaves and it is this fresh growth that suffers from the attacks of the beetle. Almost every leaf showed the characteristic twisted knot which in several cases contained a fresh laid egg. Several adult beetles were also found feeding on the tender leaves. Many of these knots were dry and showed holes, apparently those through which the adult had emerged. The insect can however be checked easily when it appears in the pest form by collecting the adults which I found very easy early in the morning when they are found exposed in numbers. The leaf knots can also be picked and destroyed.

(Figure annexed showing damage to mango leaves.)

T. V. Ramakrishna Ayyar.

120. Note on the egg-laying habits of the Agathi weevil.

(*Alcides bubo*, Fb.)

This insect feeds on Agathi (*Sesbania*), Cluster beans (*Cyamopsis*) and Indigo in South India. On Agathi it has often been noted as a serious pest in betel vine gardens where this plant is grown as a standard for the vines. The following facts in connection with egg-laying of the insect noted in the course of the investigation of its life-history and habits may be interesting.

Four pairs of the weevils were kept in captivity and daily observations were made as to the egg-laying. Before depositing the eggs, the weevil first makes an incision into the tender shoots of its foodplant and into this excavation an egg is thrust in. Each egg is laid in a separate incision, though several eggs may be laid in the same stem or shoot. The eggs are thus safely deposited inside the plant tissue one after the other.

The presence of an egg inside the succulent stem can be made out by experienced eyes from the peculiar small dirty dark brown spots on the stem surface which denote the place where the puncture was made by the weevil. On close examination, this spot shows a slight depression and the passage made by the weevil can be traced.

The following tabular statement gives an idea of the egg-laying powers of this insect :—

	Cage A* Number of eggs	Cage B* Number of eggs	Cage C* Number of eggs	Cage D* Number of eggs
19th September 1915	1	1	1	...
20th „ „	...	1	3	1
21st „ „	1	...	2	2
22nd „ „	1	...	...	6
23rd „ „	1	3	...	3
24th „ „	4	3	...	3
25th „ „	5	4	...	3
26th „ „	4	5	...	2
27th „ „	1	3	...	...
28th „ „	4	3	...	2
29th „ „	5	2	...	2
30th „ „	2	6	...	2
1st October 1915	3	1	Insects died in C & D	
2nd „ „	4	1		
3rd „ „	4	2		
4th „ „	2	3		
5th „ „	4	1		
6th „ „	2	5		
7th „ „	3	1		
8th „ „	6	2		
9th „ „	2	Female insect found missing.		
10th „ „	2			
11th „ „	2			
12th „ „	3			
13th „ „	...			

* One pair put in cage.

	Cage A* Number of eggs	Cage B* Number of eggs	Cage C* Number of eggs	Cage D* Number of eggs
14th October 1915	2			
15th „ „	2			
16th „ „	...			
17th „ „	2			
18th „ „	1			
19th „ „	2			
20th „ „	3			
21st „ „	...			
22nd „ „	1			
23rd „ „	2			
24th „ „	1			
25th „ „	1			
26th „ „	...			
27th „ „	2			
28th „ „	...			
29th „ „	...			
30th „ „	...			
31st „ „	...			
1st November 1915	Female dead.			
2nd „ „	...			
3rd „ „	...			
4th „ „	...			
5th „ „	...			
6th „ „	...			

* One pair put in cage.

It will be seen from the above that the female in cage A laid in all 85 eggs in the course of 42 days from the 19th September to the 31st October. It died on the 1st November. That in B laid 47 eggs in 20

days from the 19th September, and due to some mishap escaped from the cage on the 9th October. Those in D and C did not continue long although the female in D appeared to be pretty prolific having laid 26 eggs in 11 days.

This habit of the insect in not depositing all its eggs at one time differs from many other insects—especially moths—which lay all their eggs at a time. To this feature must be attributed the presence of the pest in the field in all its stages and at all seasons in the year. It also gives us some idea of the number of progeny the insect is capable of giving rise to, at each generation.

T. V. Ramakrishna Ayyar.

121. Early stages of Ceuthorrhynchus portulacae.

Larvæ of this weevil were found mining leaves of purslane (*Portulaca oleracea*) at Pusa on 24th September 1909 and the following notes on its early stages were made in the Insectary :—

Egg. The egg is about 0·5 mm. long, slightly less than 0·5 mm. broad, oval, ends rounded, brownish yellow, the surface smooth. It is thrust into a small hole gnawed by the female parent in the tissue of a leaf of the foodplant, only one egg being deposited in each hole, although two or even three eggs may be placed in the same leaf. The hole, in which the egg is placed, is made a little obliquely. Eggs laid on 10-11th October hatched on the morning of 13th October. When the young larva emerges it finds itself in the midst of the leaf tissue, on which it commences to feed, leaving entire the two epidermal layers of the leaf.

Larva. The newly-hatched larva is about 1 mm. long, cylindrical, legless, pale brownish-yellow, head dark brownish ; the blackish intestinal contents visible through the skin.

The full-grown larva is about 4 mm. long, cylindrical, legless, the body soft, wrinkled and uniformly yellow ; head black, smaller than prothorax which bears a black, medially-divided plate. The larva remains bent ventrally in its natural attitude. It mines the leaf of the foodplant and, though legless, can progress and, if food becomes deficient, may leave the mine and enter another leaf.

Pupation. When full-grown, the larva leaves its mine and progresses with a creeping movement down to the plant onto the soil, whereon it forms a rounded, thin-walled cocoon about 3 to 3·5 mm. in diameter. The cocoon which is formed of agglutinated earth is brittle, with its inner surface perfectly smooth ; externally it resembles a small fragment of earth. The larva pupates inside this cocoon.

Pupa. The pupa is about 2·5 to 3 mm. long, uniformly yellow, of the usual weevil type.

Life-cycle. The life-cycle is very short: egg, about two to three days; larva, four to five days (to time of forming cocoon); pupa, seven to nine days (from formation of cocoon to emergence of adult). The actual time passed in the pupal state is about five days; the larva takes about a day to complete its cocoon and to rest before pupating, and the adult beetle, which is at first yellow and darkens gradually, takes about a day and-a-half to harden before it breaks out of the cocoon.

Adult. The weevil makes short jumps like a Flea-beetle (Halticid). The same habit has been noted in the case of *Ceuthorrhynchus asperulus*. It eats holes in the leaves of *Portulaca*, frequently leaving uneaten a thin layer of one epidermal surface. It also eats the tissues of the soft stem of *Portulaca*.

This weevil proved to be an undescribed novelty which has been recently described and figured by Dr. Marshall under the name of *Ceuthorrhynchus portulacæ* (*Bull. Ent. Res.*, VI, 368-369, f. 2; Feb. 1916).

122. Life-history of Baris portulacae.

On 1st February 1912 the grubs of a weevil were found at Pusa, boring in the stems of *Portulaca oleracea*, Linn. (vernacular *Lanyia*), and eggs were also found in the stems on this date. On 14th February more grubs were collected but no more eggs were now to be found. The adult beetles emerged as follows:—

7th March, three; 10th March, seven; 20th March, eight; 26th March, three; 29th March, four; 3rd April, three; and 8th April, two.

The eggs are inserted into the stem through a small hole specially gnawed by the parent. The egg is roundish, about 0·6 mm. in diameter, pale yellow, with a soft, thin, membranous shell. The young larva, on hatching, bores into the surrounding succulent tissues of the stem and forms a tunnel longitudinally inside the stem.

The full-grown larva is 3·5 to 4·5 mm. long, of the ordinary legless Curculionid type, tapering towards each end, very pale yellow, with a brownish-yellow head. When fullfed, it forms, inside the stem, an entirely-closed, elongate-oval cocoon, which is composed of a black substance which is probably largely excrementitious. The weevil emerges by boring a hole in the stem. (Pusa Insectary.)

This species was described as new and figured by Dr. Marshall in *Bull. Ent. Res.*, VI, 369-370, f. 3 (February 1916).

123. A weevil attacking Water-melons in Bellary.

In April 1908 living weevil grubs were sent in by Y. Ramachandra Rao, Entomological Assistant in Madras, as "badly damaging water-melons on the Hagari Farm" in the Bellary District. The grub enters the melon on the side touching the ground and tunnels inside in the flesh and seeds, filling its gallery with excrement and causing decomposition of the fruit which soon rots or falls off.

The full-grown grub is about 9 mm. in length, sub-cylindrical, tapering considerably towards the head, which is yellow and about 1 to 1·25 mm. in breadth, whilst the abdominal segments are 3 mm. or more broad; the head is round with a faint median vertical furrow, from whose apex a faint white broad linear mark runs on each side to the base of the mandibles, whilst just above the mandibles is also an n-shaped dark mark. The body is soft, legless, and white or yellowish-white, curved concavely ventrally, and convexly dorsally. Spiracles yellowish, of an irregular oval shape with a central yellowish mark: the first pair on the anterior portion of the mesothorax and one pair on each of the first eight abdominal segments. There are a few minute white hairs on the head and body.

Pupation took place within the rotting fruit in an oval brownish cocoon formed of particles of the rotten fruit and of excrement closely stuck together. The pupa is of the usual Curculionid type, about 6-7 mm. in length, uniform white or yellowish-white, with minute scattered white hairs, those on the body arising from slightly tuberculated bases; the beak, legs and wings are folded ventrally, the wings between the second and third pairs of legs.

Beetles which emerged on 18th April died on 10th May in confinement. Length of life-cycle not worked out.

The beetle has been identified as an undescribed novelty by Dr. G. A. K. Marshall, who has named it *Acythopeus citrulli*. (*Bull. Ent. Res.*, VI, 372-373, f. 5; February 1916).

It also occurs in the Cuddapah District, at Coimbatore, and at Koilpatti in Tinnevelly.

124. A new weevil on Tamarisk at Pusa.

Weevil grubs, in general appearance almost exactly like those of *Hypera medicaginis* and *H. variabilis*, are found commonly on Tamarisk (*Tamarix gallica*, vernacular *Jhau*) at Pusa in February, living openly upon the green twigs which they gnaw.

Fig. 11. *Coniatus indicus.*

a, Tamarisk twigs with larvæ, cocoon, and adult weevil (×3).
b, Larva, natural size, and magnified (×7).
c, Cocoon, „ „ „ „
d, Pupa, „ „ „ „
e, Imago, „ „ „ „

The full-grown grub is about 6 mm. long, semi-cylindrical, the ventral region flattened, the segments distinct and somewhat protuberant laterally and ventrally, the ventral protuberances serving the purpose of legs which are otherwise absent. Segments thirteen in number, including the head, which is black, shiny and smaller than the other segments. The surface of the body (including thorax) is wrinkled, in colour green, with yellowish-white dorsal and lateral stripes. Locomotion is effected by gripping the twig with one end of the body, whilst the other is raised and moved in the required direction; the free end then grips the twig whilst the other extremity relinquishes its grip and is brought forward.

Pupation takes place in a roundish, brown, silken cocoon, composed of a net-work whose meshes may be quite open or closely matted together. In captivity cocoons were formed on the twigs as well as on the bottom of the cage, but under natural conditions they usually seem to be formed on the twigs.

Three specimens, which formed cocoons on 17th February 1915, pupated on 19th February, assumed imaginal characters on 1st March and emerged from the cocoons on 3rd March. Exact length of life-cycle not known, but the adult beetles are found commonly on tamarisk as late as May.

Specimens of this weevil have been determined as *Coniatus indicus*, by Dr. G. A. K. Marshall who has recently published a description (*Bull. Ent. Res.*, VI, 367-368; February 1916).

125. Athesapeuta oryzae on Paddy.

Stray specimens of this weevil were found on paddy at Coimbatore in 1908, but it is apparently not a pest of this crop. In the Krishna District it has been noted by T. V. Ramakrishna Ayyar as breeding in numbers on a species of fleshy grass—probably a *Cyperus* - growing in the paddy fields, and the same thing has been noticed in Tanjore by Y. Ramachandra Rao.

This weevil proved to be an undescribed novelty and has been named *Athesapeuta oryzæ* by Dr. G. A. K. Marshall. (*Bull. Ent. Res.*, VI, 370-371, f. 4; February 1916.)

126. Sagra nigrita as a pest of Lablab.

In October 1909 the accompanying photograph of *Sagra nigrita*, Oliv., was received from Mr. E. Ernest Green, Government Entomologist in Ceylon, with the information that "it breeds in the stems of the

climbing bean (*Dolichos lablab*) and causes large gall-like swellings in the stems."

Sagra nigrita, although only recorded from Ceylon in the *Fauna of India* volume on Chrysomelidæ, occurs in the Plains of India also and is likely to be met with as a pest of *Dolichos*.

127. Early stages of Cryptocephalus sex-signatus.

Larvæ of *Cryptocephalus sex-signatus* were found at Pusa on 10th January 1917 and the beetles emerged during the latter half of June 1917. The soft-bodied larvæ feed on dry, fallen leaves whose edges are nibbled. They are enclosed in a case, which they carry about like Psychid larvæ.

The natural attitude of the larva inside its case is a position in which it is ventrally doubled on itself as shown in figure 136. It measures from head to tip of the doubled portion about 7 mm. and from this tip to the anal extremity about 5 mm. In section it is rounded, the thoracic region being about 3 mm. broad and the doubled portion of the abdomen about 5 mm., the anal extremity tapering. Head flattened, fuscous, concave on anterior surface which is rounded in outline and measures about 2·5 mm. in diameter. Prothorax with a broad fuscous collar-like shield. Body uniform light yellow, its surface wrinkled. Three pairs of long, slender thoracic legs.

The larval case varies with the size of the enclosed larva and is from 7 to 13 mm. long and from 3·5 to 8 mm. broad, thick-walled, roughened exteriorly, tolerably hard and fuscous or blackish in colour. The case appears to be made of larval excrement, but it is not known how it is enlarged as the grub grows. At one end of the case is an opening which is just plugged by the head of the larva when the latter retreats inside its case; for locomotion the larva thrusts out its head and legs and carries the case about.

Pupation takes place inside the case, whose mouth is plugged in a manner which on casual inspection exactly resembles the way in which it is usually closed by the head of the larva. No exact details of the pupa or pupal stage were therefore noted. The adult beetle emerges from the case by breaking open a portion of its hinder end like a cap.

Pusa Insectary (Cage-slip 1590).

128. Clitea picta as a pest of Bael.

The Bael (*Ægle marmelos*) trees at Pusa are damaged considerably every year in June and July by *Clitea picta*, a Chrysomelid beetle

(From a photo. by E. Ernest Green.)

Fig. 12. *Sagra nigrita.*—Stems of *lablab* showing gall-like swellings caused by larvæ, and (on right) a stem cut open to show the larvæ. Adult beetle in centre.

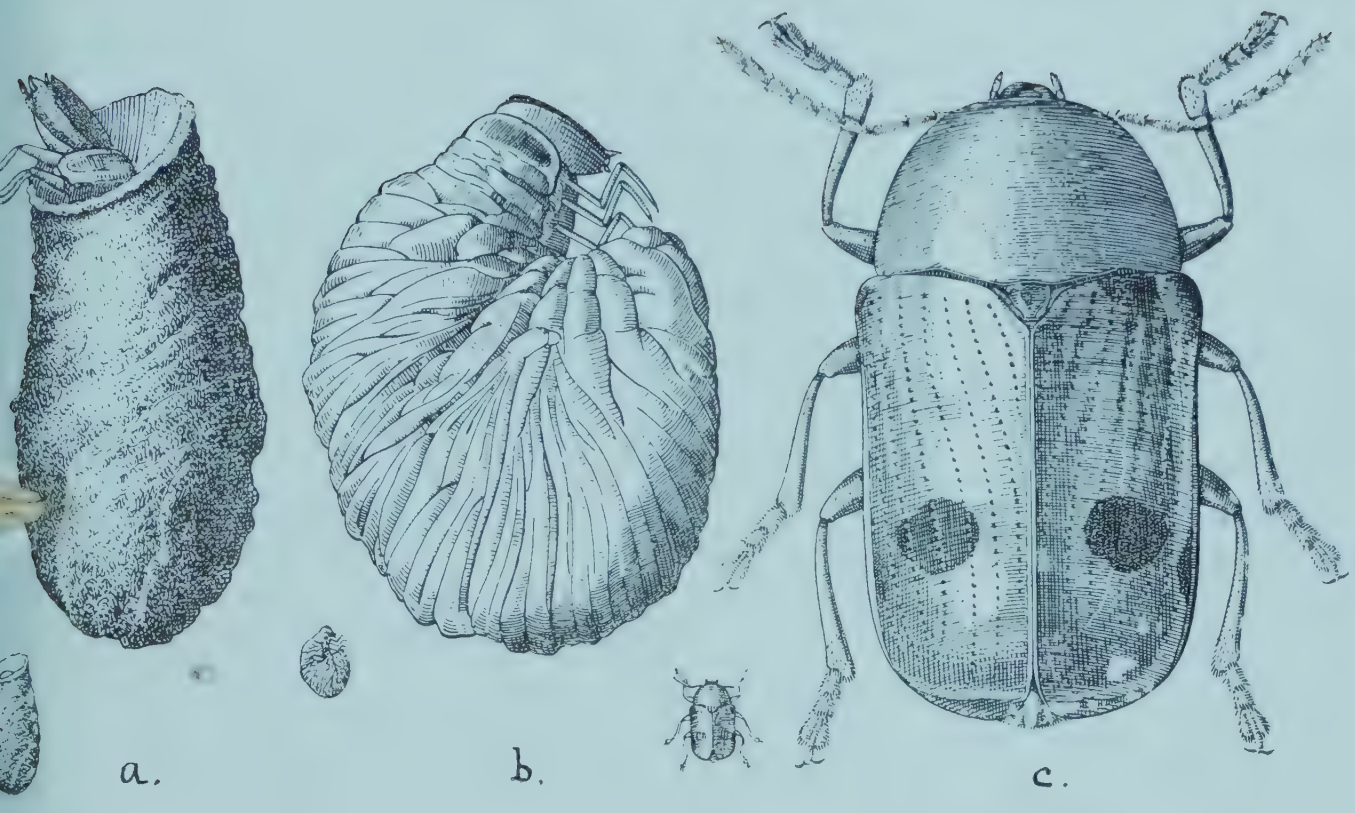


Fig. 13. *Cryptocephalus sex-signatus.*
a, Larva in case, natural size, and magnified (× 4).
b, Larva removed from case, natural size, and magnified (× 4).
c, Imago, natural size, and magnified (× 4).

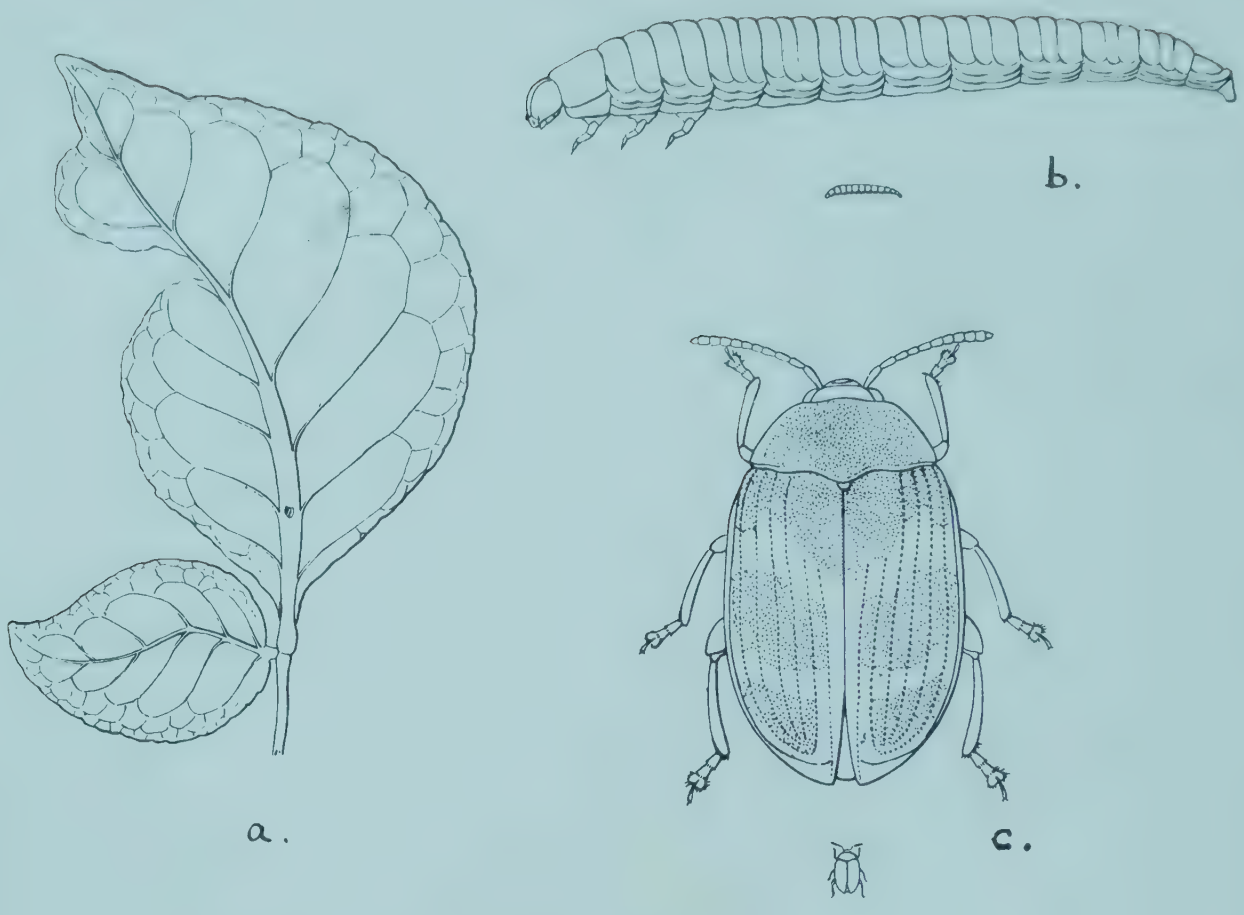


Fig. 14. *Clitea picta.*
a, *Bael* leaf bored by larva.
b, Larva, natural size, and magnified (× 9).
c, Imago „ „ „ „

Fig. 15. Leaves of *Bael* eaten by *Clitea picta.*

whose larva burrows in the midribs of leaves, tender shoots, spines, axils of branches and even occasionally in the young setting fruits, whilst the adult beetles eat holes in the leaves which are often badly riddled. (Figure 15).

The larva is about 8 mm. long and about 1·5 mm. broad, dorsally convex and ventrally compressed, of a dull-brown or orange-yellow colour, with a flattened brownish head. Prothorax with a brownish shield medially divided. Three pairs of jointed legs. The eighth abdominal segment with a small dark patch above between the spiracles. Anal plate dark, large, somewhat concave above. Anal segment with a pair of ventral fleshy pro esses, which assist in locomotion. Spiracles rounded, dark-rimmed. Minute scattered hairs on head and body, especially posteriorly. The larva bores longitudinally inside the twigs, etc., the bored parts swelling to some extent and the position of the burrow being marked by a transparent resinous exudation.

Pupation takes place either within the larval burrow or in the soil. In the case of some grubs kept in the Insectary in a glass dish with about an inch of moist earth, when full-fed they left the stems and went down into the earth until they reached the bottom of the dish, where they formed rounded cocoons of earth with a smooth interior. From three grubs which went into the earth on 10th June 1908, one beetle emerged on 15th and two on 16th June.

Pusa Insectary (Cage-slip 712) and notes by
C. S. Misra and T. Bainbrigge Fletcher.

129. Bruchus chinensis.

A cosmopolitan insect, it is found all over the world. Its habits have been studied in various parts of the globe, especially in America. In India however it has been noted only in stored produce and has been believed, so far as I am aware, not to attack crops in the field. The only Bruchid noted to be injurious to crops in fields in Madras was *Bruchus theobromæ* which was found attacking red gram (*Cajanus indicus*) pods in the fields. It however did not breed in stored produce. In January-February 1915, while examining pulses for pests in the farm I first noticed that pods of green gram, horse gram and cowpea had been attacked by Bruchids. Large numbers of pods were collected and kept under observation. Specimens of *Bruchus chinensis* were reared out from the pods of the following crops: Horse gram (*Dolichos biflorus*), green gram (*Phaseolus mungo*), cowpea (*Vigna catjang*), red gram (*Cajanus indicus*), *Ph. aconitifolius*, cluster bean (*Cyamopsis psoralioides*).

Horse gram and green gram were found to be the main host plants, only small numbers being bred from the others.

The eggs were found laid on the exterior of pods—whether green or mature—the grubs bored their way through the capsules to the seeds. When full grown they pupated in the seeds. The beetles when ready to emerge bit circular holes out of the seed capsule and flew away.

The beetles thrive very well in the stored seeds and may very badly damage the produce unless measures are taken in time. The fact that the pest is ushered into the storeroom along with the produce from the field makes it clear that one must not expect to keep the produce free from pests even if it is stored in insect-proof bins directly from the field. It shows the absolute necessity of previous fumigation before storing the produce. The eggs were found attacked by small yellow Chalcid parasites.

Y. Ramachandra Rao.

130. Early stages of Formicomus coeruleipennis.

The larvæ of of *Formicomus cæruleipennis* have been found at Pusa on several occasions underground in gram and sugarcane fields and under fallen, dry leaves of Nim (*Melia azadirachta*). Little is known of their habits, but they appear to be predaceous, as in one case a pupa of this beetle, left in the same cage as a grub, was partly eaten by the latter.

The full-grown larva is about 5 to 5½ mm. long and about 1 mm. broad, flattened, the sides almost parallel and only slightly converging posteriorly. The head is light yellow or yellowish-brown, the prothorax of about the some colour, the remaining segments creamy or dirty white. The anal segment tapers abruptly and is armed with a pair of short upturned brown-tipped processes. Hairs short and thin. Three pairs of well-developed functional thoracic legs. Locomotion is also assisted by the retractile process below the anal segment.

Pupation takes place in a thick-walled cell made of earth, the pupal period occupying about six days. There are apparently several broods in the year as full-grown grubs were found on 12th March 1916 (emerged 18th April), 16th April 1915 (emerged 1st May) and 12th August 1917 (emerged 20th August).

Pusa Insectary (Cage-slips 1205, 1374 and 1646).

131. Early stages of Gonocephalum elongatum.

Larvæ of *Gonocephalum* (*Opatrum*) *elongatum*, Fb., were found at Pusa in some numbers underground in gram and indigo fields between

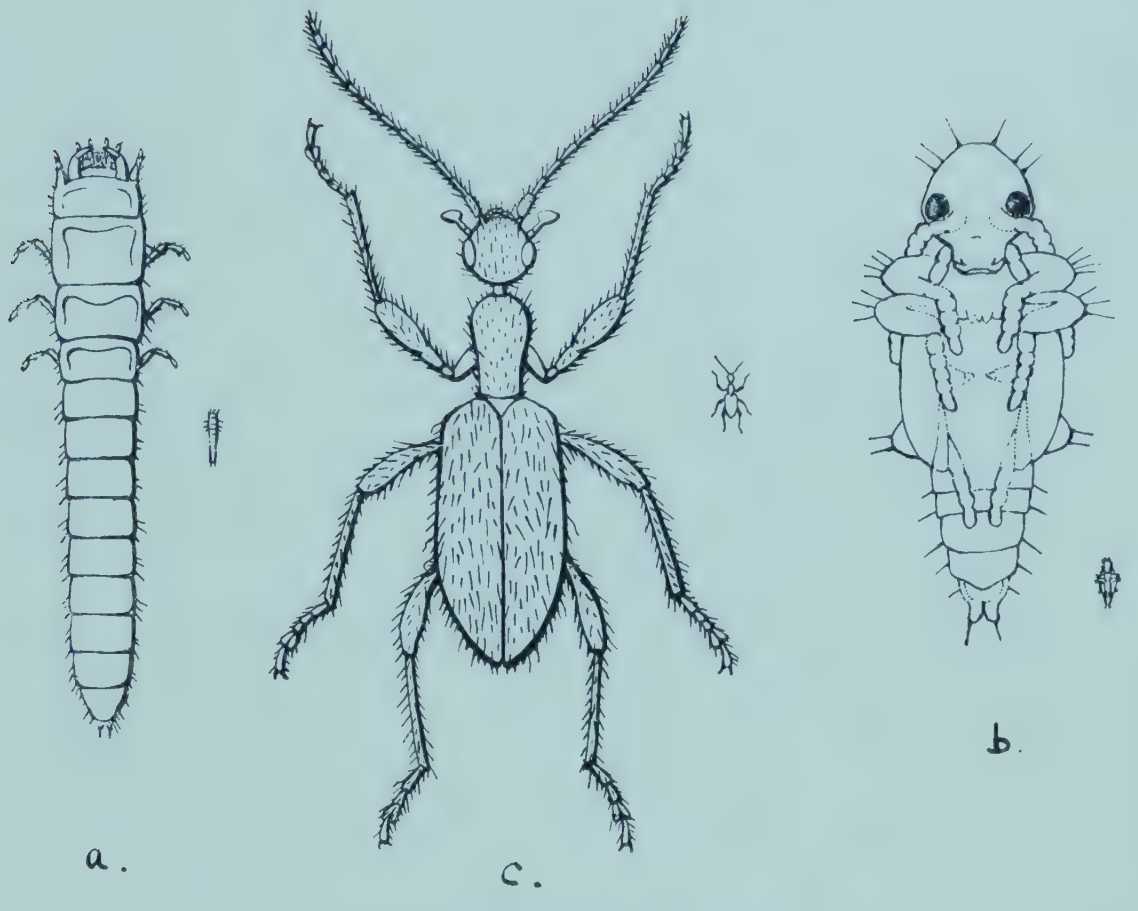


Fig. 16. *Formicomus cœruleipennis.*
a, Larva, natural size, and magnified (× 11).
b, Pupa, „ „ „ „
c, Imago, „ „ „ „

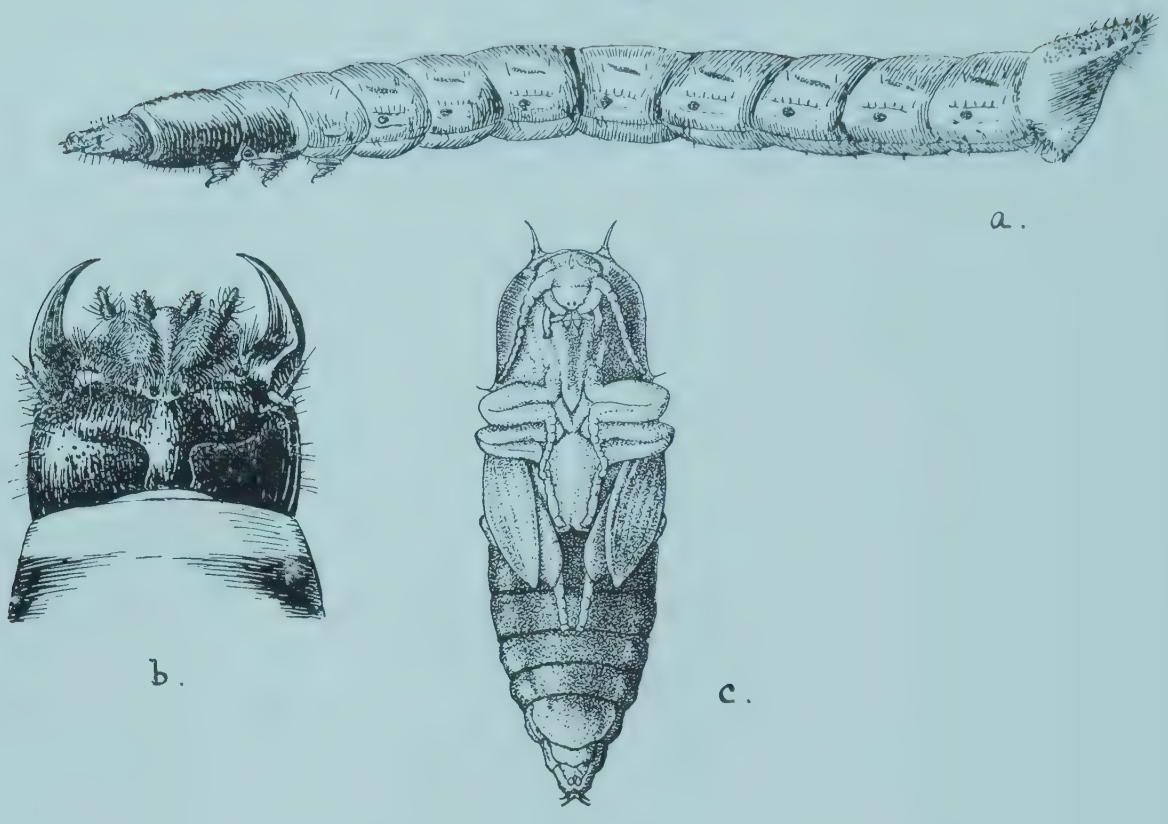


Fig. 17. *Agrypnus fuscipes.*
a, Larva, slightly magnified ($\times \frac{4}{3}$).
b, Mouth parts of larva ($\times 4$).
c, Pupa, slightly magnified ($\times \frac{4}{3}$).

Fig. 18. *Agrypnus fuscipes*, imago, natural size, and magnified ($\times 3$).

7th April and 3rd May 1915. In captivity they were found to feed, both by day and by night, on gram roots and on both fresh and dried sweet potato leaves placed on the surface of the soil, under which the larvæ hide, only emerging to feed. It seems probable that these larvæ eat any living or dead vegetable matter found near or upon the surface of the soil, and that, in their capacity of rootfeeders, they may do some damage when present in large numbers.

The larva is about 24 mm. long and 3 mm. broad across the prothorax, cylindrical, tapering slightly posteriorly, pale yellow, the integument hard and chitinous; head flattened, dull red-brown; prothorax tinged with red-brown; anal segment tapering abruptly posteriorly, its posterior margin slightly upturned and provided with minute brown tubercles surmounted by brown hairs; anal segment beneath with a retractile spically-bifurcated process, which is used in locomotion when it resembles a pair of prolegs.

Pupation takes place underground within thick-walled earthern cells, the pupal period being about nine days in April.

The pupa is about 12 mm. long, elongated, flattened and incurved ventrally, with the wing-sheaths and legs folded on the ventral region, the first seven abdominal segments with a flattened flap-like lateral process; anal segment with a pair of pointed brown-tipped processes.

Pusa Insectary (Cage-slip 1199).

132. Early stages of Agrypnus fuscipes.

In *Indian Insect Life* (page 332, fig. 212) is given a figure, copied from Westwood's *Introduction to Entomology*, of a larva which is described as "possibly that of *Agrypnus fuscipes*." Since the publication of *Indian Insect Life*, the larva of *Agrypnus fuscipes* has been found and reared on several occasions at Pusa and it is evident that, whatever the original of Westwood's figure really was, it bears little resemblance either in general appearance or in details to the true larva of *A. fuscipes*; so that an amended figure and description of this insect is required.

The larva of *Agrypnus fuscipes* lives beneath the surface of the soil and is predaceous on cockchafer grubs as a rule under natural conditions. In confinement it feeds readily on caterpillars, such as *Prodenia litura, Utetheisa pulchella, Papilio demoleus, Bombyx mori*, etc., and lepidopterous pupæ and even dead moths, such as *Agrotis ypsilon*, provided that the prey is available on the surface of the ground underneath which it is dragged for consumption, but cockchafer grubs

are much preferred as food. The adult beetle also feeds in confinement on caterpillars and pupæ.

This beetle has not as yet been reared from the egg and it is not known how long it remains in the larval stage under natural conditions, but in confinement a larva which was probably about half-grown in November 1914 did not attain the adult stage until May 1917, so that it seems probable that the normal life-cycle is two or three years, the time being perhaps dependent on abundance of available food. Larvæ may therefore be found throughout the year, but the adults appear to emerge about May-June and may live on until the next hot weather. Thus, two beetles were found at Pusa on 26th November 1915, attracted to a vessel containing palm-juice, and were kept in confinement to try and obtain eggs; one of these died on 27th January and the other on 5th February 1916. The Pusa collection contains a series of specimens taken at Pusa from May to November, four examples taken at Coimbatore from February to November and one specimen found at Samalkota on 13th May 1916.

A larva found on 7th January 1916 moulted on 30th March, prepared to pupate on 15th May, and emerged as an adult on 7th June 1916. A second larva found on 24th May 1915 was then about 60 mm. long and 8 mm. broad; it prepared to pupate on 10th June and pupated on 16th June and the adult emerged on 1st July 1915 and lived in confinement until 11th August 1915, being fed on caterpillars. A third larva, about three-fourths grown, found in the beginning of September 1915, became adult on 1st May 1916. The fourth larva, referred to above, was found at Pusa on 21st November 1914, hiding under some dry earth attached to an exposed mange root. It moulted on 25th April and on 1st May 1915 was about 46 mm. long. On 14th May 1915 it moulted, and was then about 60 mm. long. By 28th June 1915 it was 62·5 mm. long and 6·25 mm. broad, and on 28th July 1915 it moulted again. The next moult observed occurred on 11th July 1916, when the larva was about 62·5 mm. long; it had not increased in size during this year, probably due to starvation. On 20th September 1916 another moult occurred. On 21st February 1917 it was about 75 mm. long. On 21st April 1917 it cleared a space at the bottom of the cage and prepared to pupate, pupated on 1st May and emerged as an adult on 20th May 1917, after a period of over two and a half years in the larval stage.

The general appearance of the larva is shown in the figure. It is broad, flattened, and shining yellow-brown; the head, prothorax and

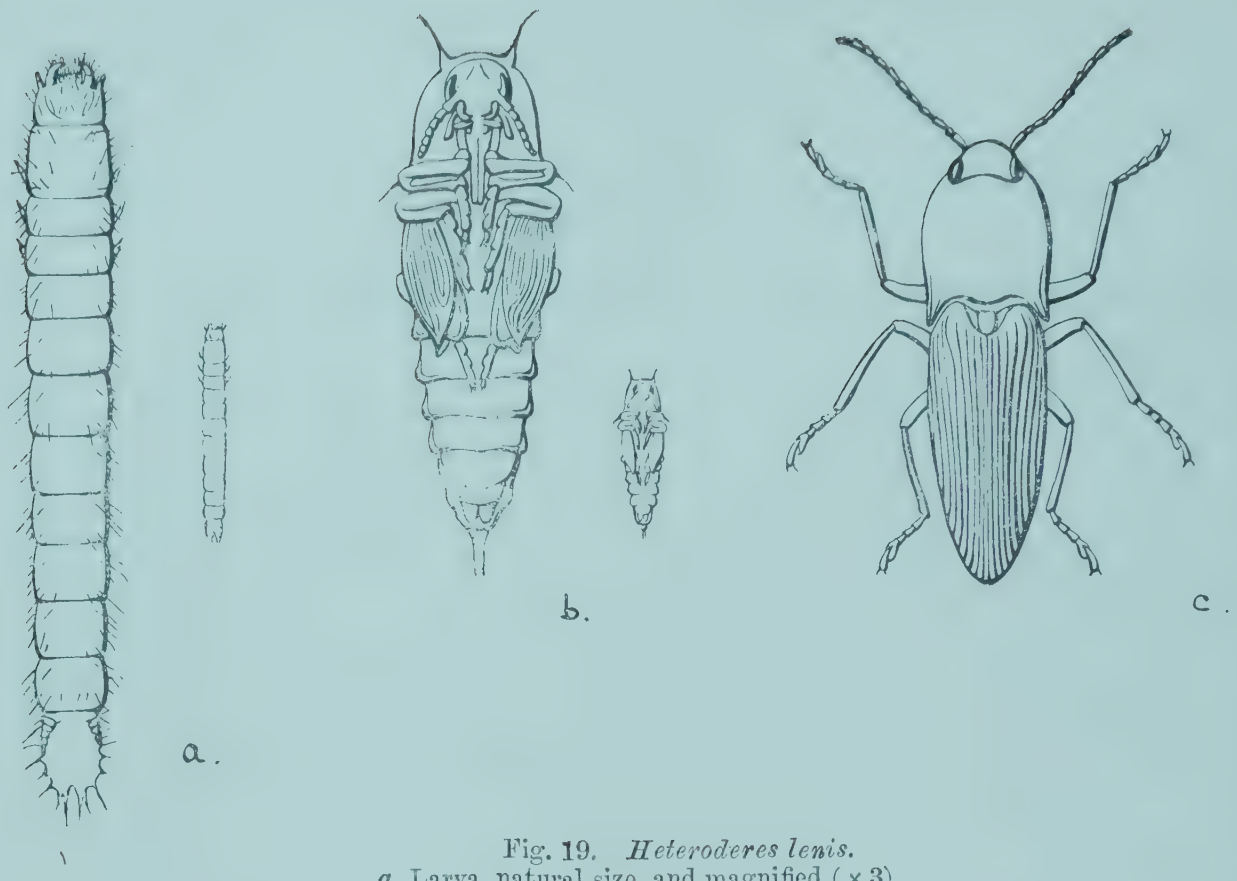


Fig. 19. *Heteroderes lenis.*
a, Larva, natural size, and magnified (× 3).
b, Pupa, „ „ „ „
c, Imago, „ „ „ „

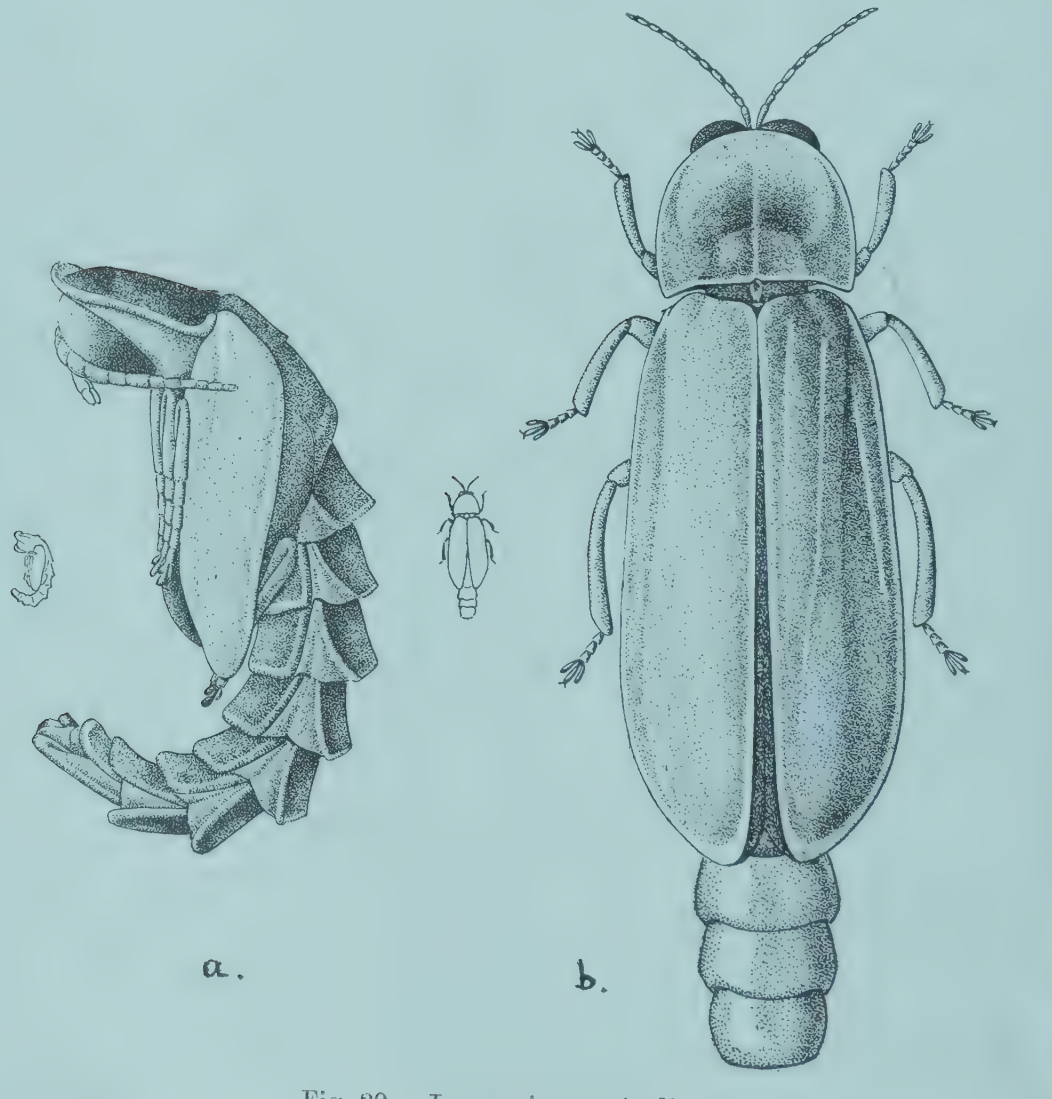


Fig. 20. *Lampyris marginella.*
a, Pupa, natural size, and magnified.
b, Imago, „ „ „

anal segment shiny dark brown and the mesothorax and metathorax shiny red-brown.

Pusa Insectary (Cage-slips 1245, 1335, 1382, 1400 and 1565).

133. Early stages of Heteroderes lenis.

Larvæ of *Heteroderes lenis*, Cand., have been found at Pusa on several occasions underground in gram and indigo fields and beneath trees. They seem to be predaceous and have been found to eat Scarabæid grubs in confinement. The following dates show the times of emergence :—

Larvæ found	Pupated	Adult emerged
26th February 1914	27th April 1914	3rd May 1914
5th May 1915	11th May 1915	20th May 1915
7th May 1915	25th June 1915	2nd July 1915
26th May 1915	15th July 1915	23rd July 1915

The length of the life-cycle is not known.

The full-grown larva is about 20 mm. long and 2 to 3 mm. broad, flattened, parallel-sided, shiny yellow-brown, lateral regions of body with rather long brown hairs; head flattened, dark red-brown; prothorax red-brown; a yellow space between head and prothorax; mesothorax and metathorax yellow with a brown tinge above; anal segment dark red-brown, flat, concave above, furnished with small black teeth laterally, posterior margin indented medially and produced at either angle into a broad tooth with bifid apex.

The pupa is 12 to 13 mm. long and 3 mm. broad, flattened, and of the usual Elaterid shape, creamy yellow; prothorax with a long spine on anterior and posterior angles.

Pusa Insectary (Cage-slips 1047, 1225 and 1260).

134. Early stages of Lampyris marginella.

Two larvæ of *Lampyris marginella*, Hope, were found at Pusa on 19th August 1916 at a depth of about three inches underground. One of these pupated on 18th November and the other on 24th November, and the adult beetles emerged on 7th and 15th December 1916 respectively.

The larva is flattened, about 15 mm. long and 2·25 mm. across the metathorax from which the body tapers in both directions. Antennæ creamy-white. Head black, much smaller than prothorax, into which it is retractile. Segments of body distinct and each partly overlapping the following segment. The dorsal region in each segment resembles a dull black plate divided medially by a yellowish dorsal line running the whole length of the body. The intersegmental soft parts and the lateral and ventral portions of the segments are yellowish in colour. The anal segment with a retractile process which has at its tip a number of retractile rod-like creamy-white processes. There are three pairs of brown thoracic legs and the retractile anal process also helps in locomotion.

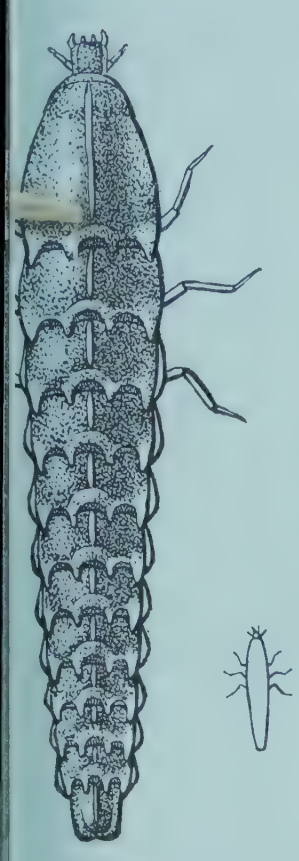
Pupation takes place on the surface of the soil, no special pupal cell being formed. The pupa is flattened, with its abdomen bent ventrally, in colour yellow, the wing-lobes, legs and antennæ free and creamy-white or very pale yellow. The posterior margins of the abdominal segments strongly produced, both dorsally and ventrally, to form small, pale yellow wing-like protuberances.

Pusa Insectary (Cage-slip 1501).

135. Larva of Luciola gorhami.

Luciola gorhami, Rits., is one of the common glow-worms at Pusa. Its larva has been found on several occasions between May and August on the surface of the soil, usually under fallen and rotting leaves. It is very active and seems to shun light. In captivity it has been found to feed on dead Lepismids, but seems to eat little and refused to touch living food. An adult beetle was reared on 10th September 1915 from larvæ collected on 5th August.

The larva is about 20 mm. long and 4 mm. broad across the hinder part of prothorax, whence the body tapers slightly posteriorly and more rapidly anteriorly, flattened, dirty yellow; head flattened, longer than broad, much smaller than prothorax beneath which it is retractile, armed with moderate-sized falcate mandibles; prothorax much elongated, anterior portion narrowed, rounded anteriorly and brownish-yellow; dorsal areas of all thoracic and abdominal segments black and chitinized and (except anal segment) with four stout spines on posterior margin, one pair subdorsal and the other at posterior angles; first to eighth abdominal segments with an additional lateral spine and a lateral fleshy protuberance surmounted by a hair; anal segment black above, with two bunches of small, yellow, cylindrical, retractile, rod-like processes which



Luciola gorhami, Larva
magnified.
nall outline figure shows
ral size.

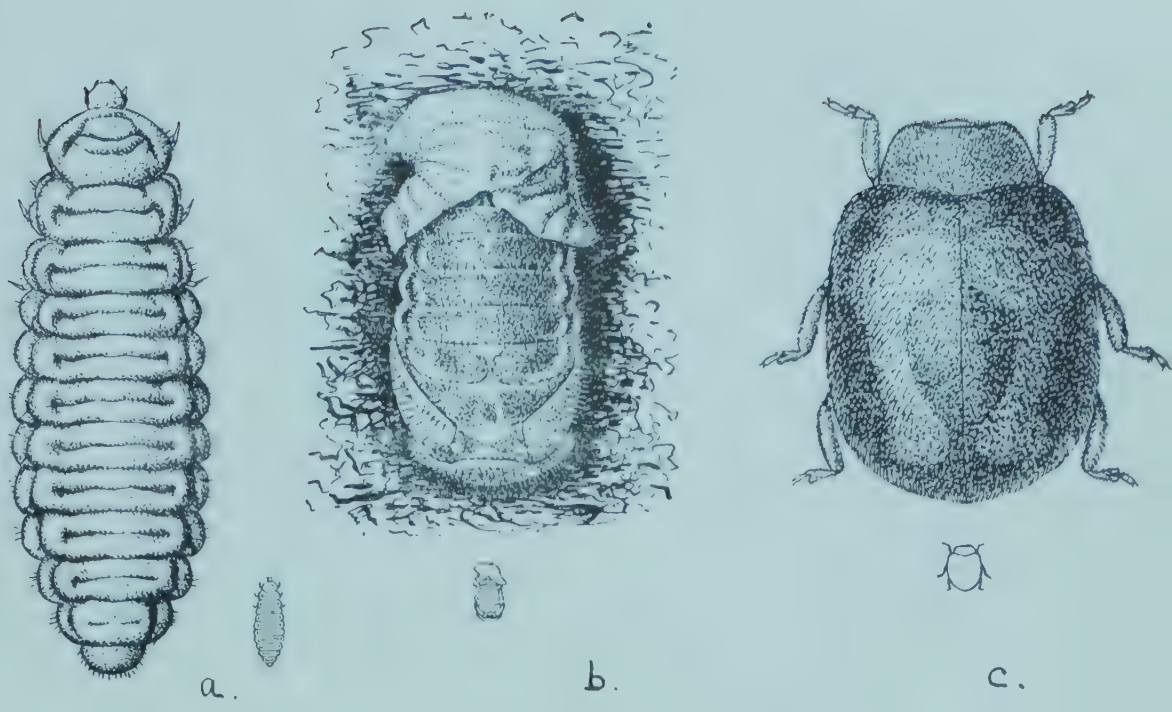


Fig. 22. *Sumnius renardi.*
a, Larva, natural size, and magnified (×7).
b, Pupa, „ „ „ „ „
c, Imago, „ „ „ „ (×8).

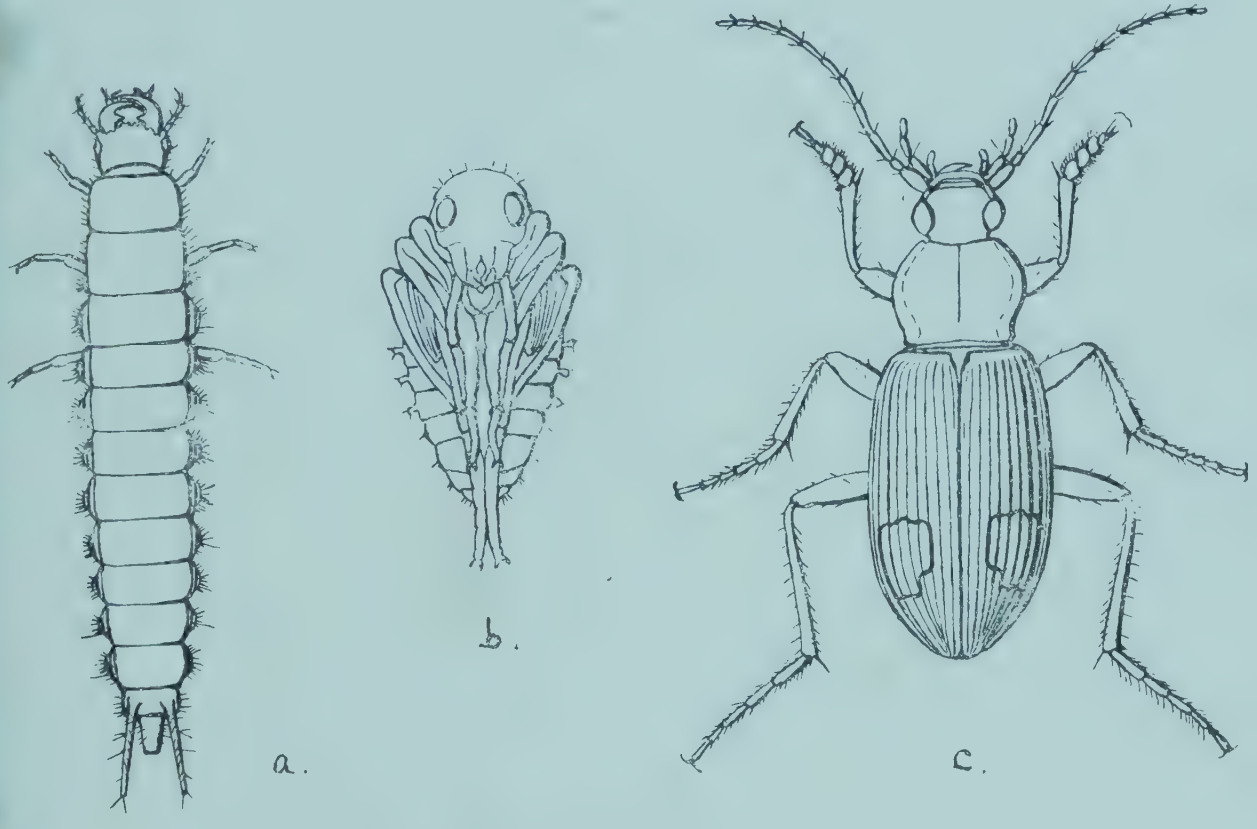


Fig. 23. *Chlænius bioculatus.*
a, Larva (×4).
b, Pupa (×4).
c, Imago (×4).

assist in locomotion ; outer posterior angles of dorsal areas of metathorax and sixth abdominal segment yellow; lateral and ventral areas dirty yellow with chitinized black spots on ventral surface, these spots bearing hairs; thoracic legs well-developed, yellow.

Pupation takes place within an oval cell formed of agglutinated earth.

Pusa Insectary (Cage-slip 1281).

136. The "Khapra" Grain-beetle in Northern India.

There has been considerable confusion regarding the identity of the Dermestid beetle which is found as a major pest of stored wheat in Northern India. In 1888 specimens were sent to England and were identified as "apparently belonging to a species of *Trogoderma* not previously represented in the British Museum Collection" (*Ind. Mus. Notes*, I, i, p. 61, where this insect is referred to as "*Kapra*"). Apparently the same insect was subsequently referred to in *Indian Insect Pests*, pp. 252-253, under the name *Æthriostoma undulata*, Mots. As noted in Entomological Note No. 37, Mr. Arrow subsequently showed that *Æthriostoma* is a synonym of *Attagenus*, and it was therefore presumed that the Indian grain-pest should be known as *Attagenus undulatus*; in the same note I recorded specimens of *Trogoderma versicolor*, Creutz., from Lyallpur (in stored wheat) on the strength of specimens sent from Pusa and so identified, though with some doubt, by Mr. Arrow.

Mr. Arrow has now examined a large series found in cargoes of wheat imported into England from Karachi and Bombay, and has concluded that the common Indian grain-infesting Dermestid belongs to a hitherto unnamed species, which he has now described as *Trogoderma khapra* in *Ann. Mag. Nat. Hist.*, (8) XIX, 481-482 (June 1917). All references to *Attagenus undulatus* in Messrs. Barnes' and Grove's Memoir (*Dept. Agric. India, Chemical Series*, IV, No. 6) should be corrected to read *Trogoderma khapra*, Arrow, and the record of *T. versicolor* (Entl. Note 37, *b*) should also refer to the same species.

137. Early stages of Sumnius renardi.

Larvæ of *Sumnius renardi* have been observed at Pusa on several occasions preying on *Monophlebus stebbingi octocaudata*, and this is the unnamed Coccinellid beetle referred to in *Entom. Mem.*, II, 7, and figured in *Indian Insect Life*, t. 84, ff, 7-9, where it is referred to (p. 308) under the name of *Aulis vestita*, Muls. On 15th March 1916 larvæ were found at Pusa on the trunk of a mango tree infested by

Monophlebus and were reared in the Insectary. The *Sumnius* larva grips a *Monophlebus* nymph with its legs, applies its mouth-parts to any convenient portion of the ventral surface of its prey, gnawing through the skin and feeding on the yellow fluid body-contents; the body of the larva is doubled over onto the back of its victim and, if the latter is large, the larva may be carried about in this posture, feeding all the while. The larvæ pupated on 12th and 15th April and the adult beetles emerged on 21st and 23rd April 1916.

The larva is about 10 mm. long and about 3 mm. broad across the middle of the body, flattened, tapering towards either extremity, segments clearly defined; each body-segment divided into two subsegments and formed into a rounded fold laterally, below these folds with a narrow deep furrow running along the whole length of body, and followed by corresponding folds along the ventral region; colour uniform light brown, rather yellowish ventrally; head small.

Pupation takes place in the usually Coccinellid manner, the larva fixing itself anally to any convenient surface, head downwards, the cast larval skin enveloping the posterior extremity of pupa.

Pusa Insectary (Cage-slip 1356).

138. Early stages of Brumus suturalis.

The early stages of *Brumus suturalis*, Fb., are referred to in *Indian Insect Life*, p. 308. It has been reared at Pusa in July 1908 from larvæ found feeding on *Phenacoccus insolitus* on leaves of *Sida spinosa* and in February 1914 from a larva found in an egg-mass of *Pseudococcus* sp. on cotton. The larvæ are sluggish and, in the case of *Phenacoccus insolitus*, were found feeding on the male puparia by thrusting their heads through one end of the cocoon. The larva is parasitized by a small black Hymenopteron which emerges through holes in the body of the larva which dies before pupation; seven parasites have been reared from a single larva.

The full-grown larva is about 5 mm. long and 2·5 mm. broad across the abdomen, which is the stoutest part of the body, tapering thence anteriorly rather abruptly, dorsal region convex, segments distinct and usually contracted, grey covered with a fine white bloom, head very small, thoracic legs well developed.

Pupation takes place on a leaf amongst the larval prey, the pupa being attacked by its anal extremity. Pupa yellow, almost wholly enclosed within the larval skin which splits longitudinally and exposes only the dorsal region of the pupa. The pupal period in July is about

seven days, of which two days are occupied in hardening the integuments and developing the colours of the adult.

Pusa Insectary (Cage-slip 733).

139. Host of Merismoderus bensoni.

On 3rd September 1916 I found a specimen of the small Paussid beetle, *Merismoderus bensoni*, Westw., being dragged down a wall in my bungalow at Pusa by three workers of *Prenolepis longipes*. At first I took it to be some victim captured by the ants, but it was being carried away from the nest and, when taken from the ants, was quite lively and unhurt. As numerous nests of this ant in and around the bungalow had just been harried by spraying, etc., it is probable that the beetle was being carried off to safety in a new nest.

This beetle was first found by Benson in 1844 and 1845 in the United Provinces, under stones and bricks associated with a black ant. *Prenolepis longipes* nests in such situations and may have been the species referred to. G. R. Dutt has also recorded the finding of *M. bensoni* in a nest of *P. longipes* (*Dept. Agric. India, Entom. Mem.*, IV, 263), so that this ant would seem to be the definite host of this Paussid beetle.

140. Early stages of Chlaenius bioculatus.

Several larvæ of *Chlænius bioculatus*. Chaud., were found at Pusa in July 1914 on sann-hemp plants, feeding on caterpillars of *Utetheisa pulchella*. The larvæ live openly on the plants, walking briskly about and boldly seizing and devouring caterpillars much larger than themselves, their prey being usually caught by the ventral surface by passing the mandibles and head beneath it. Besides *Utetheisa pulchella*, various other caterpillars are eaten and in confinement these larvæ and the adult beetles fed freely on caterpillars of *Prodenia litura*, *Polytela gloriosæ*, *Diacrisia obliqua* and *Antigastra catalaunalis*, whilst the *Chlænius* larvæ will also at times attack and devour one another, but the pupæ of the moths were not touched. *Utetheisa* larvæ were preferred. On an average, each *Chlænius* larva destroyed five, and each *Chlænius* beetle, seven caterpillars every two days.

The full-grown larva is about 12 to 15 mm. long and about 2 to 3 mm. across the middle of the body, tapering towards either end especially posteriorly and flattened in shape. Head quite flat, brownish-yellow with a dark spot on each side near base of mandibles which are much

curved and falcate, their tips considerably overlapping when closed. Antennæ and oral appendages prominent. Thoracic legs well developed, black. Body uniform black, rather shiny. Lateral regions of abdominal segments rather protuberant. Anal segment above with a pair of slender processes about 1·5 mm. long and below with an anal process which assists locomotion.

The larva enters the soil for pupation, making a hole in the earth by cutting and throwing out small pellets of earth with the mandibles. A comparatively large heap of loose earth is thrown up, the mouth of the hole usually remaining open and seldom being closed up. In confinement, the larvæ were sometimes noticed to make similar holes in the soil before they were fully fed and to remain resting near the mouth of the hole, sometimes with their head and part of the thorax protruding; but they were not observed to catch their prey when in this posture, even when caterpillars were induced to walk over the hole. This habit, however, is of interest in comparison with the habit of Cicindelid larvæ.

The period between the entry of the larva into the soil for pupation and the emergence of the adult beetle is usually about seven days, but the actual pupal period is probably four or five days, as the adult rests for about two days inside the cell, after casting off the pupal skin, in order to harden and develop its colour. The life of the adult beetle in confinement was found to be between one and two months.

Pusa Insectary (Cage-slip 1081).

141. Early stages of Chlaenius circumdatus.

A larva of *Chlænius circumdatus*, Brullé, was found underground amongst sugarcane roots at Pusa on 15th August 1917. It pupated on 25th August and the adult beetle emerged on 29th August. It was found together with larvæ of *Monolepta signata* and of another unidentified Chrysomelid beetle (C. S. 1640) and is predaceous on these larvæ. In confinement it also ate grubs of *Stictaspis ceratitina*.

The larva is about 14 mm. long and 3 mm. across the middle of the abdomen, tapering slightly in both directions from this point, flattened, with distinct segments. Head flat, with long red-brown antennæ and prominent curved jaws whose tips meet. Prothorax longer than other segments. All segments with large dorsal plates, in colour black with a bright yellowish reflection, the prothoracic plate covering the whole segment; plates laterally with short hairs. The sides and ventral region

Fig. 24. *Chlænius circumdatus.*
a, Larva, natural size, and magnified (×7).
b, Pupa, „ „ „ „
c, Imago, „ „ „ (×4).

Fig. 25. *Scarites indus.*
a, Pupa, lateral view, natural size, and magnified (× 5).
b, Pupa, ventral view (× 5).
c, Imago, natural size, and magnified (× 5).

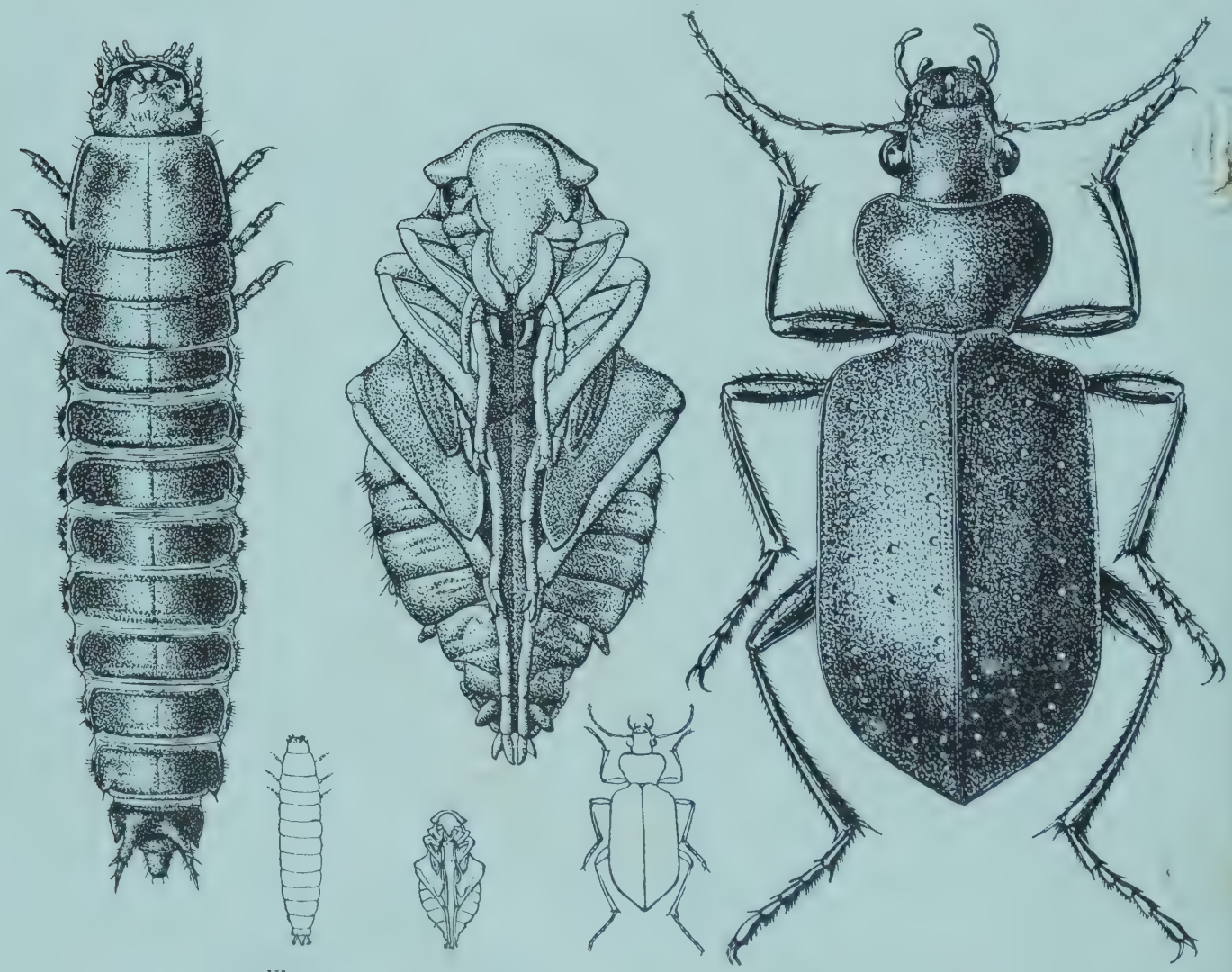


Fig. 26. *Calosoma indica.* Larva, pupa and adult beetle (× 4).
The small outline figures show the natural sizes.

of mesothorax and succeeding segments grey with slight lateral protuberances bearing small black plates from which arise short hairs. Ninth abdominal segment posteriorly with a black anal tube and dorsally with a pair of long (about 9 mm.) slender posteriorly-directed filamentous processes which are black with broad subbasal and apical pale-yellow rings. During locomotion the larva raises its hinder end in the air and, when at rest, the hinder end is raised similarly and the thoracic region is also humped upwards.

Pupation takes place on the surface of the soil without the formation of any special cell.

A second larva, found on 26th August 1917, pupated the next day, the adult beetle emerging on 1st September.

Pusa Insectary (Cage-slip 1665).

142. Chlaenius pictus.

A larva of *Chlænius pictus*, Chaud., was found in a parcel received from Cawnpore on 11th July 1915 and containing pieces of sugarcane in which cane-borer larvæ were sent. It is probable that the *Chlænius* grub was predaceous on the borer larvæ. It was much like the larva of *Chlænius bioculatus*, Chaud., with a yellow head, shining black back, yellowish-white ventral surface, three pairs of thoracic legs and a pair of slender, black posteriorly-directed processes on the anal segment. It pupated on 19th July and the adult beetle emerged on 22nd July. The beetle was found to eat cane-borer larvæ.

Pusa Insectary (Cage-slip 1259).

143. Early stages of Scarites indus.

A Carabid grub, found walking on a road at Pusa on 28th August 1917, pupated on 2nd September and on 9th September emerged as an adult of *Scarites indus*. No detailed description of the larva was made, but it was very similar in appearance to the larva of *Calosoma indica*, but the anal cerci were provided with small joints and with brown hairs arising from these joints as well as from the tips of the cerci.

Pusa Insectary (Cage-slip 1679).

144. Calosoma indica predaceous on caterpillars.

In April 1916 larvæ and adults of *Calosoma indica*, Hope, were found commonly at Peshawar in wheat and oat fields infested with

caterpillars of *Cirphis unipuncta*, being found in cracks in the soil or under clods and shooks. Both larvæ and adults were found to feed freely on the *Cirphis* caterpillars. Of the larvæ brought to Pusa one pupated on 9th May and attained the adult stage on 13th May.

In October 1917 many of the *Calosoma* grubs were found at Pusa in a field of *Phaseolus aconitifolius*, preying on caterpillars of *Plusia*, *Remigia* and *Thermesia*. The grubs were active and bold, running briskly about and freely attacking the caterpillars. Fifteen grubs, collected on 7th October, were placed in a cage and all went into the earth but, on searching the cage a week later, only one grub was found alive and it is evident that these larvæ are cannibalistic when confined in close quarters.

The full-grown larva is flattened, about 30 mm. long and about 6 mm. broad, all the segments covered dorsally with a shining black plate, the lateral and ventral areas greyish and membraneous with black plates. Three pairs of well-developed legs are present. Anal segment with an anal tube which helps in locomotion and dorsally with a pair of long single-branched spines, posterior margins of segments produced externally into short spinous processes.

The pupa is white and about 17 mm. long and about 7 mm. broad across the first abdominal segment, the head narrowed anteriorly and the abdomen tapering posteriorly. Head doubled onto ventral surface and body incurved ventrally. Appendages free. This Pusa example pupated on 19th October and the adult emerged on 25th October 1917.

Pusa Insectary (Cage-slips 1386, 1721).

145. Broscus punctatus predaceous on caterpillars.

In February 1914 adult beetles of *Broscus punctatus*, Klug, were found commonly at Pusa under the soil in gram fields infested with larvæ of *Agrotis ypsilon*. Six beetles were collected on 26th February 1914 and were kept under observation in the Insectary, and it was found that these beetles fed freely on larvæ of *Agrotis ypsilon*, *Prodenia litura*, *Pieris brassicæ* and *Chilo simplex*. Under natural conditions of living in the soil, the beetles hunt for the caterpillars of *Agrotis ypsilon* beneath the surface of the soil, chase them to the surface, and there attack and devour their prey, whose internal parts are preferred, the skin being rejected as a rule. Pupæ of *Agrotis ypsilon* were not touched. The number of caterpillars destroyed daily by each beetle is

Fig. 27. *Siphunculina funicola*, (× 20.)

Fig. 28. Eggs of *Siphunculina funicola*, (× 50.)

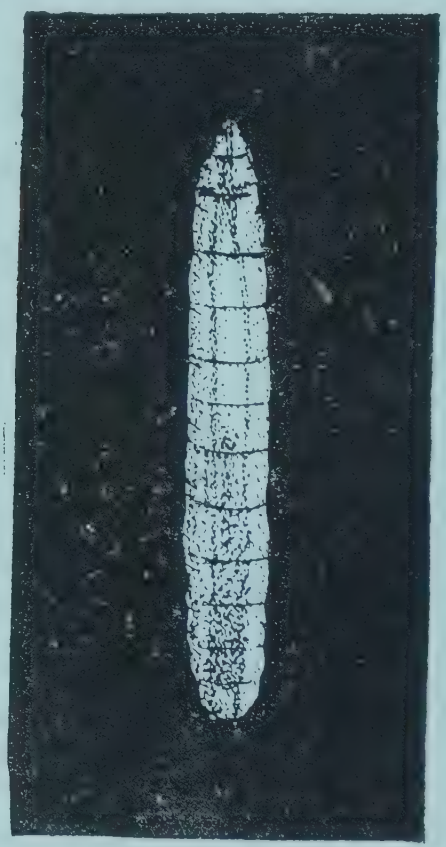


Fig. 29. Young maggot of *Siphunculina funicola*.

comparatively small, one large *Agrotis* or two *Prodenia* larvæ sufficing as a rule, but, on the other hand, the adult life of the beetle is a long one, extending over at least three months, from March to June, so that each individual beetle ends its life with a considerable total destruction of caterpillars to its credit. The early stages are as yet unknown.

Pusa Insectary (Cage-slip 1048).

146. The life-history and habits of "the Eye fly", Siphunculina funicola, De Meij.

Introduction. There are several insects living around us, with which we are very familiar but about many of which our knowledge is very limited. The insect under consideratien here, *viz.*, the Eye fly, may be quoted as an example. As a source of annoyance we are as much familiar with the eye fly as we are with the house fly, mosquito or the bed bug. But very little is known or on record regarding the bionomics of this insect, except that at certain months in the year it is found a veritable nuisance to man. And it is only in very recent publications of entomology even a mention of it is made. It is expected, therefore, that the following notes, of course with many lacunæ still to be filled up, might add a little to our knowledge of this very familiar but little known insect.

*The insect.** This troublesome fly is a very small shining black creature resembling the house fly in general structure but much smaller in size than the latter, measuring only 1½ mm. in length (Fig. 27). It is shining black in colour, though on closer examination the eyes and the tarsi of the legs appear reddish brown. The two wings are transparent and iridescent. The insect enjoys a wide distribution all over India. It is also found in Ceylon and Java. It has been found both along the seacoast and in fairly high elevations such as Bangalore, Bellary, etc.

Except during the cold months from November to February this insect is found all through the year; but it is abundant during the

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* *Siphonella-Microneurum*-Becker.
Microneurum funicola, de Meijere, 1905.
Siphonella funicola, de Meij., 1905.
References.—Lefroy—Indian Insect Life, p. 627.
Fletcher—Some South Indian Insects, p. 355.
Castellani and Chalmers—Manual of Tropical Medicine, p. 700.
Green.— Mosquitos and Eye flies (*Spolia Zeylanica*, V, 18, 1908).

summer months and especially so during the short intervals of warm weather after the South-West Monsoon sets in.

Habits of the insect. As the very name of the insect indicates, the fly has the habit of hovering about our faces and often settling at the corners of the eyes. Being a minute creature it often gets into one's eyes and this is frequently the case with children with unclean faces. It is felt as a veritable nuisance when one is engaged in duties demanding the close attention of the eyes such as reading, writing, etc. The insect appears to have a special liking for the lachrymal secretion and perspiration. It greedily feeds on blood as is often seen by its settling on razor wounds. The fly is also found commonly feeding on open sores, scratches and other wounds. In certain cases the eye fly appears a worse nuisance than the house fly. The latter very rarely troubles our eyes or settles on the face, except perhaps at times when one is asleep, and it is hardly ever found in such places as libraries, laboratories, etc., away from houses. The eye fly on the other hand follows the man to such places and interferes with his work considerably. This is very often felt on some of those still, warm days when there is no breeze. A peculiar habit of this insect and one which might help us in destroying it is its characteristic way of swarming in numbers on slender bits of ropes and strings such as those hanging from roofs, punkha-ropes, etc. The fly prefers old bits of fibre rope or cloth to fresh ones. Such aerial colonies are more commonly found under thatched roofs where numerous fibrous bits are found hanging. These swarms are always found away and protected from the winds. The fly has also been found settling in numbers in drying up *Nim* leaves kept under the roofs of houses. The fibrous bits hanging from sparrows' nests in the roofs of houses also offer a favourable place for these flies to congregate. Once what appeared a dark patch of paint on a rafter high up the roof of a house really happened to be a colony of eye flies—this appeared to be quite a departure from the ordinary habit of settling on ropes, etc. On another occasion I noticed the key of a mahogany microscope box kept in its hole being completely covered with a colony of eye flies. Even a small area of the box surface around the key hole was found occupied by numerous flies. Stray individuals are not uncommonly found hovering about window panes. The fly, as it hovers about, produces a low humming noise, which, though annoying, is not as pronounced as that of its nocturnal cousin—the mosquito.

Life-history. All attempts to discover the natural breeding haunts of the eye fly have so far been unsuccessful. Every kind of available rotting animal and vegetable matter was examined. Kitchen refuse,

Fig. 30. Maggot (later stage) of *Siphunculina funicola* (×30.)

Fig. 31. Pupa of *Siphunculina funicola* (×30.

refuse from the stables, silo pits and drains were all tried but without success. As the time of the appearance of the insect in numbers corresponds with the fruit season, rotting *nim* and mango fruits were also tried but without any favourable result. Quite accidentally a few eye flies emerged from earth brought in from the Insectary garden to be put into a breeding jar for quite a different purpose. Another time, the flies appeared in the jars in which *Oxya* (a grasshopper) eggs were kept in damp sand. In two cases, among a number of Drosophilids a few eye flies also came out from the rotting fibrous matter in coconut and palmyra trees.

However, it was possible to get an idea of the different stages of the insect and the time occupied by each, by following the development of the insect from eggs which were laid by flies in captivity. In June 1914, I got a number of eye flies clinging to a string and put them into a jar with fresh cow dung. The flies deposited eggs on this material within a short time and grew to maturity in this medium.

Egg. The cream white eggs were laid either singly (Fig. 28), or in groups in the cracks and grooves of the lump of cow dung and often just a little below the surface. Each egg is cigar-shaped and shows under the lens longitudinal striations. One pole of the egg is broader than the other which is more or less pointed. In three days the eggs hatch out into minute maggots.

The maggot. The fresh hatched maggot is a minute transparent white wriggling creature measuring a millimetre in length (Fig. 29). The head end is pointed. On the second day the mouth parts appear dark and the internal organs at the hinder regions show as reddish brown patches through the transparent body wall. The maggot feels the necessity for some moisture as is seen by its torpidity when the cow dung fluid gets evaporated and by its activity when a drop or two of liquid is added. The maggot grows in this medium and assumes its full grown condition in a week's time (Fig. 30). When about to pupate it leaves the liquid medium and approaches the drier portions of the cage such as dry dung or soil and there changes into the pupa.

The pupa. The puparium is reddish brown with the anterior end slightly flattened and with a pair of projections (Fig. 31). The spiracles are found as in the larva; the posterior end has another pair of spiracles. The pupation period occupies a week after which the adult fly emerges.

The following tabular statement might give an idea of the different developmental periods occupied by stages in the different rearings.

Date when eggs were laid	Date of hatching	Date of pupation	Date of emergence of fly	Number of days from egg to adult
8th June 1914	10th June 1914	17th June 1914	23rd June 1914	16
8th June 1914	10th June 1914	18th June 1914	26th June 1914	19
8th June 1914	10th June 1914	19th June 1914	25th June 1914	18
8th June 1914	10th June 1914	19th June 1914	26th June 1914	19
13th June 1914	16th June 1914	...	30th June 1914	18
13th June 1914	17th June 1914	25th June 1914	1st July 1914	18
13th June 1914	17th June 1914	26th June 1914	2nd July 1914	19
20th June 1914	...	29th June 1914	6th July 1914	17

From the above it is evident that the life-history of the eye fly from egg to imago, in captivity at any rate, occupies from sixteen to twenty days. With regard to the longevity of the adult fly under favourable conditions it might live for a week or more. Flies kept in cages fed on sugar have lived ten and twelve days.

Returning again to the breeding haunts of the insect it may be stated that other substances besides cow dung were also tried to get the flies deposit eggs on. Among others were bits of mango fruit, horse dung, rotting fibrous matter from trunks of palmyra tree, vegetable mould, soil from gutters near kitchens, etc. In none of these did the flies lay eggs in captivity.

Some insects of this family—Oscinidæ—are known to breed in plant tissue in different countries while a few are scavengers breeding on decaying vegetable tissue. One insect *Oscinis theæ*[1] is recorded as leaf miner on tea in India. Williston[2] speaks of the larvæ of *Siphunculina* having been bred from the plant *cirsium*.

From these facts it is quite possible that the natural breeding haunts of the eye fly may be some common plant or plants. Further investigations will have to show this to be so or not.

The eye fly as a criminal. There is a good deal of circumstantial evidence to bring the eye fly under the category of disease-carrying insects.

[1] See *Indian Museum Notes*.
[2] See his *North American Diptera*, p. 310.

It is a common sight during the months when the fly is very prevalent to find a number of people suffering from eye complaints. This is especially so in children. The disease "sore eye", very common during the summer months, has been found to spread freely among school children and the eye fly is found visiting such eyes. The cause of eye complaints is often attributed to eating too many mangoes. But it has not yet definitely been proved how far the eye fly plays the part of a carrier of the disease germ. Flies similar to our eye fly, according to various authorities, [1] are said to cause some eye disease in the southern states of America. The eye fly is suspected by Castellani [2] to be a carrier of the Koch-Weeks bacillus which is the cause of severe conjunctivitis. Further investigations in this direction by medical entomologists might reveal the true position of the eye fly as an offender.

Control measures. As in the case of the house flies, mosquitos, etc., the most effective and radical control measure consists in tackling the breeding haunts of this insect, and so long as these remain a mystery we have to content ourselves by resorting to other methods for the present. As stated above, the habit of the insect of congregating in swarms on ropes, etc., in many cases helps us in destroying these colonies easily; with the help of a wide-mouthed jar or a killing bottle, several colonies can be trapped and destroyed. Such swarms can also be burnt with a torch. This is more successfully done early in the morning or late in the evening. Household sanitation and personal cleanliness also keep away this pest to a great extent. According to Castellani the eye fly objects to substances like Odol. Eucalyptus oil rubbed on the coat collar is said to keep away the fly from hovering about our face.

Until our knowledge of the habits and life-history of this insect is considerably advanced we shall have to rely upon such temporary measures of relief.

It may be added in conclusion that there are still several important facts regarding this insect which are quite unknown and which require investigation. Among these are the following:—

(i) The number of broods passed by the eye fly in the year.
(ii) Whether the fly has a resting or hibernating period and if so in what stage, adult or pupa.
(iii) Number of eggs laid by one fly.
(iv) The nocturnal enemies, if any, of this insect.
(v) The natural breeding haunts.

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[1] *See* Kellogg, p. 350. Doane.
[2] *Manual of Tropical Medicine*, p. 700.

(vi) Chemotropic characters of the fly. Experiments with different kinds of chemicals, such as essential oils, etc., to attract the fly.

T. V. Ramakrishna Ayyar.

147 A Fruit-fly in Plantains.

Mr. K. D. Shroff, Entomological Assistant in Burma, has sent us some specimens of *Chætodacus diversus* reared from plantain fruits at Mandalay, and writes as follows :—

> "The fruits, in which I found the maggots of this fly, were quite sound from outside and not injured by any animals. Before I came across this pest, I had [? heard] several times that the plantains were also attacked by maggots. I found the pest in a variety locally known as "yakaing nga-pyaw." It is an inferior variety of plantain. In the whole bunch only five or six fruits were found infested. Better varieties of plantain are also said to be attacked, but the pest does not appear to have spread to any appreciable extent like mango and peach flies. If the attacked fruits are peeled, small dark grey spots are found on the pulp, which indicate the presence of maggots working inside the pulp".

This is, I think, the first record of the occurrence of a Fruit-fly in plantains within our limits.

T. Bainbrigge Fletcher.

148. A Fruit-fly attacking Bamboos.

At Pusa in July and August a fairly high proportion of young bamboo shoots is found to be dead and drying up and, on examination, the majority of these dead shoots are found to contain a large number of pinkish-grey maggots of *Stictaspis ceratitina*, which consume the whole interior of the shoot, only the sheaths being left. So far as has been observed, the death of the shoots is due to the attack of these maggots. Attempts were made, by confining adult flies over the growing shoots, to infect them artificially, but no positive infection could be obtained ; it is possible that these negative results were due to the fact that the adult flies used for these experiments were all freshly emerged.

Stictaspis striata has also been bred from bamboo at Peradeniya by Green, and it seems probable that the species of this genus are more injurious to young bamboo growth than has been suspected hitherto.

T. Bainbrigge Fletcher.

149. Myiopardalis pardalina.

This Fruit-fly, well-known as a pest of melons in North-Western India, was reared in large numbers from fruit of *Cucumis trigonus* at Pusa in August and September 1915. This is, I think, the first record of its natural occurrence south of the Punjab.

T. Bainbrigge Fletcher.

150. Anoplomus flexuosus.

A single specimen of *Anoplomus flexuosus*, Bezzi (*Mem. Ind. Mus.*, III, 100-102, t. 8, f. 12) was taken, in company with various other flies, on ripe mulberry fruit at Jeolikote, Kumaon, on 10th May 1915.

T. Bainbrigge Fletcher.

151. Early stages of Clitellaria heminopla.

The larvæ of this Stratiomyiid were found at Coimbatore in March 1914, along with grubs of a Monommid, attacking the decaying tissues of the thick bark of the stem of *Moringa pterygosperma* which had been cut down some time back. The maggots, which were of a grey brown colour, were somewhat flattened probably in adaptation to a life under bark. The body tapered to a point anteriorly and terminated in a blunt end posteriorly. The head is lance-head-like and horny and the segments of the body are very clearly marked. When full grown the larvæ choose a safe locality, wherein to pass the pupal stage. The pupa is formed inside the hardened skin of the larva and emerges as a brownish black fly with a faint greyish pubescence parts of the body. The fly has an extraordinary resemblance to some of the smaller bees.

Y. Ramachandra Rao.

152. The Gingelly Gall-fly.

The insect figured under the above name in *Some South Indian Insects*, page 364, figures 224 and 225, has now been named *Asphondylia sesami*, n. sp., by Dr. E. P. Felt, whose description has recently appeared in the "Canadian Entomologist," Vol. XLVIII, pages 31-33 (January 1916).

153. The Cotton-bud Cecidomyiad.

The Cecidomyiad fly figured in *Some South Indian Insects*, pages 363-364, figure 223, as a species of *Contarinia*, has been named *Dasyneura gossypii*, n. sp., by Dr. E. P. Felt, whose description has recently appeared in the "Canadian Entomologist," Vol. XLVIII, pages 29-30 (January 1916).

154. New Indian Gall Midges.

In an endeavour to discover plants in which *Pachydiplosis oryzæ*, Wood-Mason, might breed in the absence of paddy (rice), various grasses bearing deformations similar to those produced by the above named midge were found on three different grasses by Mr. Y. Ramachandra Rao, and a number of flies bred out and submitted for study through Mr. T. V. Ramakrishna, Acting Government Entomologist of the Agricultural College and Research Institute. Several new species obtained are described below, and it is worthy of note that *Orseolia cynodontis*, Kieff. & Mass., was reared not only from *Cynodon dactylon* but is also recorded as issuing in association with *Pseudhormomyia fluvialis* and *Lasioptera fluitans* both characterized below. In addition, females of another species were obtained, and it is probable that further rearings would result in the securing of other gall midges.

Lasioptera fluitans, Felt.

The specimens were received from T. V. Ramakrishna, Acting Government Entomologist, Coimbatore, India, under date of August 4, 1916, accompanied by the statement that they were reared from galls in *Panicum fluitans* along with *Pseudhormomyia fluvialis* described below. The specimens were labelled 3, XII, '15; South India, Coimbatore, from *Panicum fluitans*, Y. R. Rao coll.

Length 1·5 mm. Antennæ extending to the base of the abdomen, sparsely haired, dark brown; 18 segments, the fifth with a length equal to its diameter, the terminal segment narrowly to broadly oval; face with a conspicuous patch of white scales. Palpi yellowish, the first segment irregularly subquadrate, the second with a length nearly twice its diameter, the third a little longer than the second, more slender, and the fourth a little longer and more slender than the third. Mesonotum a shining dark brown. Scutellum dark reddish brown apically, yellowish basally, postscutellum dark brown. Abdomen almost black, with lunate submedian silvery spots on segments 1 to 5, the apex of the terminal segment yellowish. Wings hyaline, costa dark brown, the third vein

uniting with the yellowish costal spot at the distal third; halteres mostly pale yellowish orange; coxæ and femora basally yellowish orange, the distal portion of the femora, tibiæ and tarsi a nearly uniform dark brown. Ovipositor nearly as long as the abdomen, a thick group of moderately stout, hooked spines at the base of the slender, sparsely setose, tapering lobes, the latter with a length nearly three times the width.

Length 1·5 mm. Antennæ dark brown, sparsely haired, extending to the base of the abdomen, the fifth with a length one-fourth greater than its diameter, the terminal segment narrowly oval. Palpi: first segment subquadrate, the second with a length twice its diameter, broader, the third a little longer and more slender and the fourth a little longer and more slender than the third. Colorational characters wanting; claws moderately stout, strongly curved, unidentate, the pulvilli as long as the claws. Genitalia: basal clasp segment rather short, stout; terminal clasp segment long, swollen basally, subacute apically; dorsal plate short, broad, deeply and triangularly emarginate, the lobes narrowly rounded distally; ventral plate long and tapering to the narrowly rounded apex; harpes long, stout, tapering apically, with an irregular quadrate tooth; style long, slender, narrowly rounded distally.
Type Cecid. a2779.

Pseudhormomyia fluvialis, Felt.

The midge described below is provisionally referred to this genus and was received from Mr. T. V. Ramakrishna, Acting Government Entomologist, Coimbatore, India, under date of August 4, 1916. The species is stated by him to be very abundant locally, breeding on *Panicum fluitans*, a common grass in wet land areas, galls being found both in the terminal and the side shoots. The specimens were labelled No. 1, 29, VII, 1916, South India, Coimbatore, from *Panicum fluitans*, Y. R. Rao coll.

Length 3 mm. Antennæ one-half longer than the body, rather thickly haired, yellowish brown; 14 segments, the fifth with the stems approximately equal, each with a length one-half greater than the diameter; the basal enlargement subglobose, the distal pyriform and with a constriction near the middle, each enlargement with a whorl of long, stout setæ, the basal with one and the distal with two circumfili, the loops, moderately long and thick; terminal segment with the basal portion of the stem produced with a length five times its diameter, the distal enlargement shaped like a truncate cone, the length one-half greater than its diameter and apically with an equally long moderately

stout, fulsiform appendage. Palpi: first segment subquadrate, the second narrowly oval, with a length nearly twice its diameter, the third twice the length of the second, slender. Mesonotum purplish brown, the submedian lines sparsely haired. Scutellum and postscutellum yellowish brown. Abdomen rather thickly haired, purplish brown, the genitalia yellowish. Wings hyaline, the third vein uniting with the margin well beyond the apex; halteres yellowish basally, yellowish brown apically; anterior coxæ dark brown, the mid and hind coxæ yellowish brown; legs a nearly uniform yellowish brown, the hind tarsal segments yellowish straw; claws moderately stout, strongly curved, simple, the pulvilli as long as the claws. Genitalia: basal clasp segment moderately stout and unusually long, the length being nearly three times the greater diameter and with an obtuse internal lobe near the basal half; terminal clasp segment stout, slightly curved and with a length about thrice its diameter; dorsal plate nearly divided, the lobes long and tapering to a narrowly rounded apex; ventral plate long, broad, constricted near the distal third and broadly rounded apically; style long, slender.

Length 3 mm. Antennæ nearly as long as the body, sparsely haired, light brown; 14 subcylindrical segments, the fifth with a stem one-fifth the length of the subcylindrical basal enlargement, which latter has a length five times its diameter, a distinct constriction near the basal third, whorls of long, stout setæ basally and subapically and short-looped, circumfili near the basal third and apically, the latter connected by a longitudinal filum; terminal segment reduced, tapering slightly distally, with a length about four times its diameter and apically a short, stout, subfusiform appendage. Palpi: first segment broadly oval, the second a little longer, more slender, and the third more than twice the length of the second and more slender. Mesonotum dark reddish brown, to dark brown, the submedian lines almost naked. Scutellum and postscutellum yellowish brown, the abdomen sparsely haired, reddish brown, the segments narrowly margined posteriorly with yellowish brown, the eighth and ninth mostly yellowish brown. Wings hyaline; halteres mostly yellowish brown. Coxæ yellowish brown, the legs mostly a chestnut brown; claws more slender than in the male. Ovipositor short, stout, the lobes broad, with a length about twice the diameter and tapering slightly to a narrowly rounded apex. Other characters practically as in the opposite sex.

Exuviæ. Length 5·5 mm., mostly light yellowish brown; antennal horns long, narrowly conical; antennal cases extending to the base of the abdomen, the wing cases to the second abdominal segment and the leg

...ses of the first, second and third pairs extending to the third, fourth and fifth abdominal segments respectively; the dorsum of each abdominal segment with a transverse, irregular row of stout, chitinous, unidentate spines, the anterior ones approximately half the size of the posterior series.

Type Cecid. a2777.

Pseudhormomyia cornea, Felt.

The midges provisionally referred to this genus were received from T. V. Ramakrishna, Acting Government Entomologist, Coimbatore, India, under date of August 4, 1916, accompanied by the statement that they breed in a grass, *Ischæmum ciliare*, the galls being formed mostly in the side shoots, and labelled No. 4, 2, VIII, '16, South India, Coimbatore, from *Ischæmum ciliare*, Y. R. Rao coll.

Length 2·5 mm. Antennæ nearly as long as the body, sparsely haired, light brown; 14 segments, the fifth having the stems each with a length one-half greater than the diameter, the basal enlargement subglobose, the distal strongly constricted and with a length over twice its diameter; whorls of moderately stout setæ occur upon both enlargements and on the distal two circumfili, the loops being moderately long, stout, ...nd rather numerous. Palpi: first segment irregular, subquadrate, the second irregularly oval, the third more than twice the length of the second, more slender. Mesonotum reddish brown. Scutellum and postscutellum yellowish brown. Abdomen yellowish brown, the genitalia yellowish. Wings hyaline, the third vein uniting with the margin well beyond the apex; halteres yellowish. Legs mostly yellowish brown. Genitalia: basal clasp segment with a length two and one-half times its diameter and a distinct internal lobe near the basal half; terminal clasp segment stout, curved and with a length over twice its diameter; dorsal plate long, broad, deeply and triangularly emarginate, the lobes tapering mostly internally to a narrowly rounded, thickly setose apex; ventral plate long, broadly, thickly setose; posterior margin narrowly rounded; style stout, tapering to a narrowly rounded apex.

Length 3 mm. Antennæ nearly as long as the body, thickly haired, yellowish brown; 14 segments, the fifth with a stem one-third the length of the cylindrical basal enlargement, which latter has a length about four times its diameter; low circumfili occur at the basal third ...d apically; terminal segment with the basal part subcylindric and having a length four times its diameter; apically there is an irregular, fusiform appendage about half the length of the basal portion. Palpi:

first segment irregularly quadrate, the second as long as the first and the third twice the length of the second, slender. Mesonotum dark reddish, the submedian lines sparsely haired. Scutellum and postscutellum dark yellowish brown. Abdomen rather thickly haired, pale reddish, the terminal segments and ovipositor mostly yellowish; halteres mostly pale straw; coxæ and legs mostly dark straw; claws moderately slender, strongly curved, simple, the pulvilli as long as the claws. Ovipositor short, moderately stout, the lobes sparsely haired, narrowly oval and with a length two and one-half times the width.

Type Cecid. a2778.

(E. P. Felt; *Entl News*, XXVIII, pp. 73-76; Feb. 1917.)

155. Indian Gall Midges.

The writer has been privileged, through the courtesy of Mr. Ramakrishna Ayyar of South India, to study two small collections of gall midges reared or obtained from the vicinity of various grasses. In addition to data given in a preceding paper,* we would record the rearing of the rice or paddy gall midge, *Pachydiplosis oryzæ*, Wood-Mason, from *Panicum stagninum*, and the capture of adults, referable with very little question to this species, in light traps. The specimens taken in early October, 1916, were heavy with eggs. *Pseudhormomyia fluvialis*, Felt, was reared, in addition to foodplants previously recorded, from *Panicum punctatum*, and both this species and the closely related *P. cornea* are here referred to *Dyodiplosis*, Rubs. Below we describe one new species and all the stages of a very interesting midge, the adults previously being unknown and tentatively referred to *Oligotrophus*, Latr.

Hormomyia ischæmi, Kieff.

1910 Kieffer, J. J., *Royal Botanic Gardens, Kew, Bull.* No. 3, p. 71, (*Oligotrophus*).

Adults and specimens of the gall of this insect, provisionally referred to *Hormomyia*, were received from Mr. T. V. Ramakrishna, Coimbatore, S. India, under date of November 9, 1916, accompanied by a statement that the insects were reared from a gall on *Ischæmum pilosum* and were very likely identical with the species described from the larva and gall by Dr. Kieffer as *Oligotrophus ischæmi*, which latter is probable though not certain. The larva described by Dr. Kieffer, of this species, is evidently a young stage, since the large size of the midges preclude their developing from such a small full-grown larva.

* Ent. News, XXVIII, 73-76.

Gall. Length 11 to 18 cm., diameter 3 to 4 mm. This is a reddish, cylindrical tube pointed at the apex and sheathed at the base by scale-like leaves. The interior is hollow for practically its whole length and emergence is through a small hole near the tip (characters in part from L. A. Boodle, p. 70, *l.c.*).

Egg. Length 0·2 mm., ovate, cylindrical, whitish and apparently produced in great numbers, since several hundred were found in a vial containing a portion of a gall and one dilapidated female.

Larva. It is probable, as stated above, that the whitish larva described by Dr. Kieffer, *l.c.*, p. 71, is a very young stage or does not belong to this species. A free translation of Dr. Kieffer's description follows:

Larva white, length 2 mm., smooth, the spiny warts very fine and situated on the ventral part of the last two thoracic segments and all of the abdominal segments. The papillæ are all simple, save the eight terminal ones, which are provided with very short, scarcely distinct hairs; the pleural and sternal papillæ are equally large; the mesial pleural papillæ arranged in groups of three; the anterior, ventral and posterior papillæ small and hardly apparent. Antennal segment rounded, deeply emarginate in the middle, dorsally with spare granulations on the anterior portion, the posterior part nearly smooth; breastbone yellow, large, sessile, as long as large and with two triangular teeth which have a length twice the width of the base and are separated by a broadly rounded emargination.

Exuvium ♂. Length 5 mm., moderately stout, yellowish transparent, the thoracic horns slender, slightly curved, nearly cylindrical and with a length about five times the diameter. Antennal cases probably extending to the base of the abdomen and with triangular basal processes with a length about three times the diameter of the base and thickened apically; the wing cases reaching to the tip of the second abdominal segment, and the leg cases to the fifth or sixth abdominal segments; the dorsum of the latter slightly chitinized and with an irregular series of three or four transverse rows of chitinous spines.

♂. Length 3·5 mm. Antennæ about as long as the body, thickly haired, yellowish brown; 14 segments, the fifth almost trinodose, the stems with a length $1\frac{1}{4}$ and $1\frac{1}{2}$ times their diameters, respectively; basal enlargement subglobose, with a sparse subbasal whorl of stout setæ and a subapical circumfilum, the loops numerous, with a length about half the diameter of the enlargement and forming an almost double row, the latter being true of the middle and distal fili; terminal

segment somewhat produced, the basal portion of the stem with a length about twice its diameter, the distal enlargement subcylindric and with a length nearly three times its diameter, and apically a large, fusiform appendage, a rudimentary segment.

Palpi; first segment irregularly ovoid, the second a little longer and stouter, the third more than twice the length of the second and tapering uniformly from a somewhat swollen base. Eyes holoptic.

Mesonotum dark reddish brown. Scutellum concolorous, postscutellum dark reddish brown. Abdomen dark yellowish brown, somewhat variable, the genitalia yellowish; the terminal clasp segment fuscous apically.

Wings subhyaline, brownish, shorter than the body, the third vein, uniting with the margin well beyond the apex, the fifth vein joining the posterior margin at the distal fourth, its branch beyond the basal half; halteres yellowish basally, brownish yellow apically.

Coxæ reddish brown; legs mostly yellowish brown, the tarsi somewhat darker.

Genitalia; basal clasp segment short, broad, swollen basally; terminal clasp segment moderately long, nearly straight; dorsal plate short, broad, deeply and narrowly emarginate, the lobes narrowly rounded; ventral plate a little longer, broad, broadly rounded apically.

♀. Length 5 mm. Antennæ probably three-fourths the lengh of the body, sparsely haired, dark brown; 14 segments, the fifth with a stem one-fourth the length of the subcylindric basal enlargement, which latter has a length about four times its diameter and low, looped circumfili near the basal third and subapically.

Palpi; first segment irregular, the second a little longer, subquadrate, the third more than twice the length of the second, slender and nearly uniform in diameter.

Mesonotum dark brownish black, the submedian lines sparsely haired. Scutellum and postscutellum concolorous, the former with a few golden hairs apically. Abdomen shining dark brownish black, sparsely clothed with short hairs.

Wings slightly fuscous and only about two-thirds the length of the abdomen, the third vein uniting with the margin just beyond the apex of the wing, the fifth with the indistinct anterior branch joining the posterior margin at the distal fourth and the posterior branch beyond the basal half; halteres yellowish orange basally, fuscous subapically.

Coxæ and legs a nearly uniform dark brown; claws moderately stout, strongly curved subapically, simple; pulvilli nearly as long as the claws.

Ovipositor short, the lobes irregularly oval, with a length about one-half greater than the width and rather thickly setose.

Type Cecid. a 2781.

Dyodiplosis andropogonis, Felt.

The species described below was received from Mr. T. V. Ramakrishna, Acting Government Entomologist, Agricultural College and Research Institute, Coimbatore, South India, under date of November 9, 1916, accompanied by a statement to the effect that the midges were reared from galls in a common perennial grass, *Andropogon annulatus*, at Adoni, Bellary District, September 23, 1916, and labelled Y. R. Rao coll. These insects are similar to, though quite distinct from, *Pseudhormomyia fluvialis*, Felt, and *P. cornea*, Felt, both received earlier from the same correspondent. These last two species are congeneric with the one to be characterized and now referred to the genus *Dyodiplosis*.

♂. Length 2 mm. Antennæ one-half longer than the body, thickly haired, yellowish brown; 14 segments, the stems with a length one and one-fourth and two and one-half times their diameters, respectively, the distal enlargement with a length one and three-fourths greater than its diameter and only slightly constricted near the basal third as compared with *D. fluvialis*. The circumfili are fine and moderately long; terminal segment produced, the basal portion of the stem with a length three times its diameter, the distal enlargement cylindric, with a length fully three times its diameter and apically a moderately stout, rather long, conical process.

Palpi; first segment short, irregular, with a length about one-half greater than its diameter, the second a little longer and broader, the third about as long as the two preceding, more slender.

Mesonotum purplish brown, the submedian lines and posterior median areas yellowish. Scutellum and postscutellum mostly pale yellowish. Abdomen sparsely haired, a variable dark brown basally, yellowish brown apically.

Wings hyaline; halteres yellowish basally, light brown apically.

Legs mostly a pale straw.

Genitalia; basal clasp segment moderately long, stout; terminal clasp segment distinctly swollen basally, tapering; dorsal plate deeply and triangularly emarginate, the divergent lobes narrowly rounded;

ventral plate long, broad, subtruncate apically, the posterior border slightly and roundly emarginate; style a little longer than the ventral plate.

♀. Length 3 mm. Antennæ nearly as long as the body, sparsely haired, dark reddish brown; 14 segments, the fifth with a stem one-third the length of the cylindric basal enlargement, which latter has a length about four times its diameter and sparse whorls of stout setæ subbasally and apically; terminal segment hardly produced, the enlargement with a length three and one-half times its diameter and apically a rather broad subconical process.

Abdomen sparsely haired, mostly dark reddish brown, the seventh segment and the lobes of the ovipositor yellowish brown; halteres yellowish basally, reddish brown apically; claws long, rather slender, strongly curved apically, the pulvilli a little shorter than the claws.

Ovipositor short, tapering, the lobes with a length over twice the width and tapering irregularly to a narrowly rounded, setose apex. Otherwise as in the male.

Type Cecid. a 2782.

(E. P. Felt; *Entoml. News,* XXVIII, pages 369-372; Oct. 1917.)

156. Notes on some South Indian Cecidomyiads causing galls in grasses.

Paddy is subject to a peculiar disease known in the Tamil tracts as "Anaikombu" (Elephant-tusk) or "Thandeethu" (the bearing of earless stalks), in the Telugu districts as "Kodu" and "Koyyala Tegulu" (stick disease), as "Kané" in Canarese (S. Canara District), and in popular English as "silver-shoots." This malady is characterized by the formation in the young plant of a long hollow shoot, carrying, when fresh, a rudimentary leaf at the tip. This out-growth is formed at the expense of the normal development of the bud culminating in the formation of the ear-head, and is, therefore, a distinct source of loss to the ryot. Till about two years ago, the silver-shoot on paddy was a puzzle and was either ascribed to the action of fungi or bacteria, or attributed to that ultimate refuge of a scientist in despair—a constitutional disease. It was only in 1914 when good specimens were received from Pudukottah from one of the ex-students of the Agricultural College, Coimbatore, that the real nature of the disease became apparent.

The silver-shoot is in fact a gall caused by a gall-insect. A small reddish fly belonging to the Family Cecidomyiadæ—identified as

Pachydiplosis oryzæ by Dr. E. P. Felt of the New York State Museum, Albany—is the specific cause of the malformation. This fly lays elongate-oval reddish eggs measuring half a millimetre in length on the hairs of the ligules, or on the lower surface of the basal parts of leaves, and rarely, also, on their upper surface, especially in young tillers. The tiny young larvæ creep down between the leaf-sheaths till they reach the growing point of the apical of the side buds. On entering the interior of the buds, they seem to lacerate their tender tissues and feed on their nutritious juices. Whether by actual feeding or by continual irritation, an oval chamber is formed around the maggot in the tissues of the growing point. Further normal apical growth being stopped, all the nutrition is directed to the walls of this chamber, which elongates like a normal internode. By the time the out-growth begins to be visible, the maggot will generally have turned into a pupa and in about six days will be ready to emerge as a fly. When about to transform, the pupa, with the help of the dorsal spines of its abdominal segments, wriggles up the hollow tube, and, boring a hole at the tip with its frontal spines, partially projects out. The adult now emerges, and flies away, leaving the empty pupal skin at the tip of the hollow shoots. This disease is found in paddy generally only in the rainy season and is altogether rare in the dry season crop. As, even in places where paddy is not raised in the dry season, the fly re-appears on paddy with the advent of the rains, it is evident it cannot depend solely on paddy and must have an alternate foodplant, presumably some perennial wild grass, wherein it tides over the dry weather. With the object of finding out such host-plants a scrutinizing search was made among the various grasses in the wet land area of the Central Farm and was attended with rather remarkable results. Never was the paradox that "a man may keep his eyes wide open and yet not see" more truly illustrated. *Panicum fluitans* is a very common grass in the wet land area at Coimbatore growing abundantly on the field *bunds* and along the banks of channels. Throughout the year except in February and March, a gall-midge breeds in this grass causing gall-formations in profusion, 20 to 30 galls sometimes having been found to occur on one single plant. Yet this common-grass did not draw my notice, till by chance one day I tumbled on it in the course of my search for the egg-masses of *Oxya velox*. Again, no grass is more familiarly known or more abundant than *Cynodon dactylon*—"Hariali." This is also attacked by a Cecidomyiad fly which affects the tips of shoots and causes the formation of a body of the shape of a miniature pine-apple. This object is in reality a collective gall from which later on 3 to 8 and sometimes 12 or more hollow shoots appear, each giving rise to a

fly. These conspicuous objects were not taken notice of and, if at all they were, they were believed to be caused by fungi.

These are instances of how one is apt to overlook very obvious things and one may well imagine Nature crying out in extreme pity—like Aunt Betsey Trotwood in "David Copperfield"—"Blind, Blind, Blind."

At Coimbatore, after very careful search, three grasses were, in the first instance, found to exhibit such formations. They were:—

(1) *Panicum fluitans.*
(2) *Cynodon dactylon.*
(3) *Ischæmum ciliare.*

Quite recently, in November 1916, these formations were noted also in the following three grasses at Coimbatore, *viz.*:—

(4) *Andropogon schœnanthus.*
(5) „ *pertusus.*
(6) *Apluda varia.*

When galls were first noted on some of these grasses, in the excitement of the discovery, I had the temerity to congratulate myself on having found out the host-plants of the paddy gall-fly, but on comparing freshly-bred specimens of all these gall-flies side by side, I was forced to the conclusion that I had to do with several different species altogether, each confining itself to its own particular foodplant. Many of these gall-flies have been sent to Professor E. P. Felt for accurate determination.

Between July and October 1916, I had opportunities of visiting the Government farm at Palur, S. Arcot District, several places in the Bellary and Kurnool districts, and Samalkota and Anakapalle in the Northern Circars. As leisure and opportunities allowed, I continued my search for gall formations among the wild grasses in these various localities. The results were rather surprising. Instead of the formation of the "silver-shoot" on paddy being an isolated and extraordinay phenomenon, it became evident that it was one of common occurrence in many grasses.

The following grasses were noted to be subject to the attack of gall-flies. As the time needed for collecting them in sufficient quantities was not at my disposal, and breeding appliances were not at hand, the gall-midges could not be reared out in all cases. Again the degree of parasitization of the galls was so high that the chances of rearing the flies were considerably minimized. It would be very interesting if future worker in this line would try and breed out the flies from each grass and have their identity established.

EXPLANATION OF FIG. 32.

1. The picture on the left shows three galls in *Panicum fluitans*; the one on the right, two similar formations in *Apluda varia*. In the latter, the grey object dimly seen at the angle of the leaf axis on the shaded background at the top represents the empty pupal skin sticking out from the tip of the hollow gall.
2. Compound galls in various stages of formation in *Cynodon dactylon*.
3. Galls in *Andropogon pertusus*. They are not distinct in the photographs, but their positions are indicated by the cross-marks.
4. Shows a single shoot with the central gall in *Andropogon pertusus*. The pale object seen feebly projecting from the shoot on the shaded background is the pupal skin.

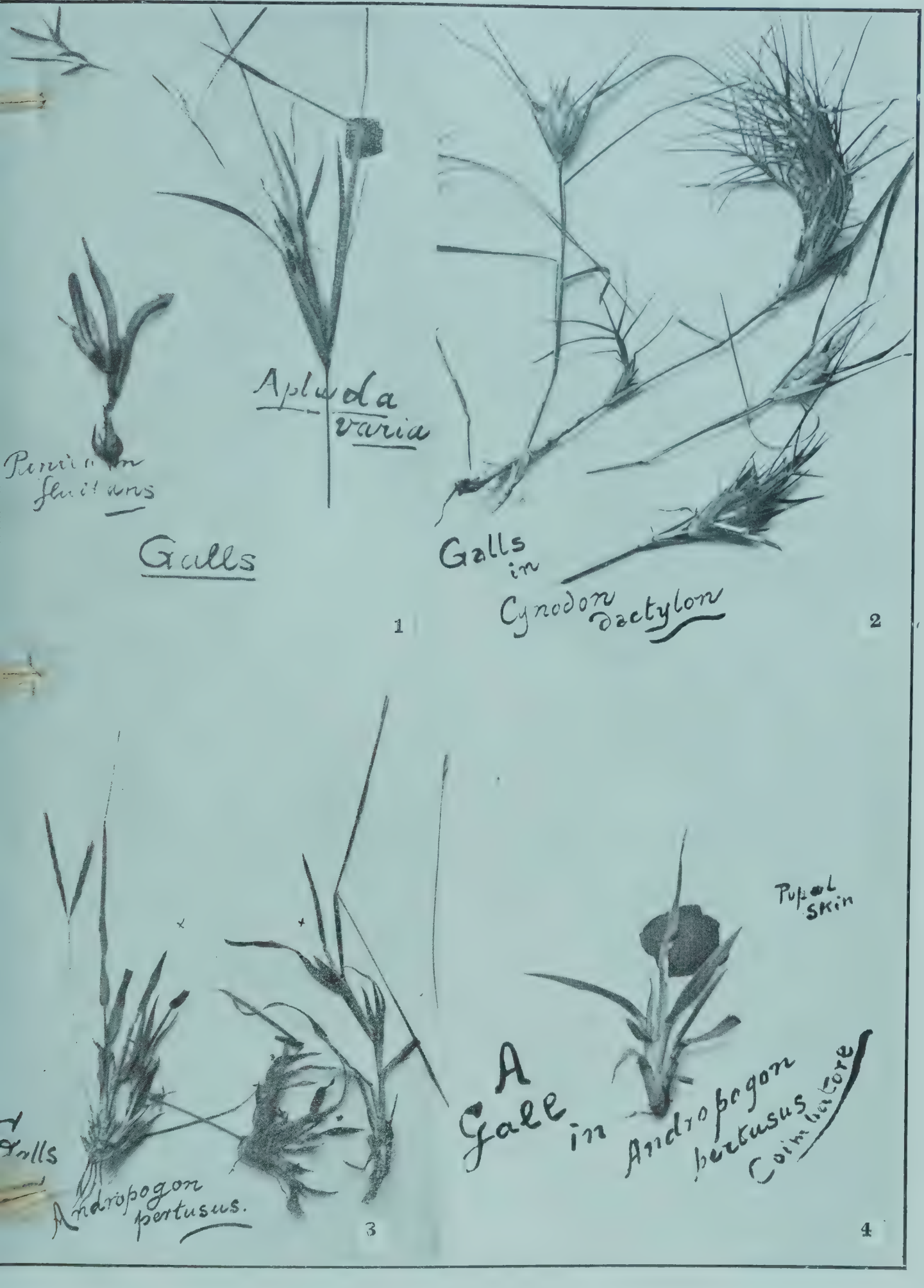


Fig. 32. Cecidomyiad galls in grasses.

1. *Panicum fluitans*, Retz. This grass is semi-aquatic and is found growing on field *bunds* in wet lands on the banks of canals, in the beds of streams and in shallow tanks. It has so far been noted by me only in Coimbatore and Bellary districts and in Bangalore. Galls have been found on this grass at Coimbatore and in the following places in the Bellary District, *viz.*, Hadagalli, Kottur, Siruguppa and Yemmiganur. The flies reared at Coimbatore and in the Bellary District were identical.

The life-history of this fly* has been fully studied by me. The female scatters its 300 to 350 eggs singly along the pronounced grooves of the upper surface of the leaves. The eggs are elongate-oval, half a millimetre long, and slightly reddish in colour. They hatch in about three days into tiny active maggots, which crawl by instinct down the leaf and, insinuating themselves between the leaf-sheath and the stem, creep down until they reach the growing tips of either the apical or the side buds. Each bud is occupied only by a single maggot. The shoot begins to show a swelling in about a week or two and the typical hollow shoot emerges in two or three weeks. Though hatching at one time out of the same batch of eggs, the maggots that enter the apical buds complete their development more quickly (at least a week earlier) than those affecting the axillary ones; and invariably the apical galls are much larger in size than the axillary ones. The full-grown maggot is of pale brown colour and possesses a well-marked breast-plate, the anterior ends of which are prolonged into two pointed horns. The freshly formed pupa is milk-white, but later turns bright-pink. The adult emerges in six days. The female is pale brown and possesses a huge reddish abdomen bulged with eggs, while the male is somewhat darker and more slender in form. Most of the eggs are laid during the first night. The male flies seem to go for a drink, soon after emergence, while the females do not display any such thirst.

2. *Panicum punctatum*. A grass very nearly allied to *P. fluitans* but more thoroughly aquatic. It was collected by me at Samalkota, Godavari District, and showed profuse gall-formations. The fly reared out was identical with *Dyodiplosis fluvialis* reared from *P. fluitans*. The flies reared from galls of *P. punctatum* freely laid eggs on *P. fluitans* at Coimbatore. The maggots that hatched out induced typical gall-formations in *P. fluitans* and flies emerged normally from them.

3. *Cynodon dactylon*. As already noted, a collective gall is formed in this grass, from which 2 to 12 hollow shoots may emerge. Such galls

*Through the courtesy of the Ag. Government Entomologist, Coimbatore, information has been received that this fly has been identified by Prof. Felt as *Dyodiplosis* (*Pseudhormomyia*) *fluvialis*.

were noted on this grass at Coimbatore, Palur (S. Arcot District), Samalkota (Godavari District), and Anakapalle (Vizagapatam District). The fly which has been identified as *Orseolia cynodontis*, Kief. and Mass., is smaller, comparatively more thick-set and darker than *Dyodiplosis fluvialis*. The life-history of this fly has also been studied by me. The eggs are elongate, reddish and about one-third of a millimetre long and are laid in batches of 3 to 20 along the under (and rarely also on the upper) surface of the top leaves of a shoot. The maggots hatch out in three days and, creeping between the leaf-sheaths, reach the rudiments of the apical and axillary buds of the shoot. Owing to the irritation caused by the maggots, several of the side-buds of the shoot begin to develop their galls simultaneouly, so that the tip of the shoot bulges out gradually and assumes the pine-apple form. When mature, the hollow shoots appear at the tip and the flies emerge later on. The time taken by the fly to develop into the adult from the egg is about three to six weeks.

4. *Ischæmum ciliare*. This is also a common grass at Coimbatore in the wet lands. The galls found on this grass are smaller and shorter than those on *P. fluitans* and are developed usually from the axillary buds towards the base of the plant. Flies have been reared and are quite distinct; the wings being more distinctly smoky and the body much darker than in the other species of Coimbatore. It has been named by Felt as *Dyodiplosis* (*Pseudhormomiya*) *cornea*, n. sp.

Similar galls were also noted at Samalkota in an allied grass (?).

5. *Panicum stagninum*—an aquatic plant common at Samalkota and Coimbatore along canals, in shallow tanks and along water channels in the wet lands. At Samalkota, in October 1916, silver-shoots were noted in profusion on this grass. Large quantities of this grass were collected and taken to Coimbatore for rearing, but as the galls were heavily parasitized, only small numbers of flies could be reared out. These flies resembled *Pachydiplosis oryzæ* in almost all characters, and have been forwarded to Professor Felt for exact identification.[1] As sufficiently large numbers of flies could not be reared out actual breeding experiments to find whether flies from *P. stagninum* would breed on paddy could not be undertaken and their identity could not, therefore, be solved in a direct manner.

At Samalkota the eggs of this fly were found laid as in paddy, either on the hairs of the rudimentary ligules, or on the leaves or leaf-stalks in the neighbourhood of the ligular region. The silver-shoots were also

[1] The flies have been found identical with *Pachydiplosis oryzæ* from paddy by Prof. Felt.

similarly very long. Though abundant at Coimbatore, this grass has not shown any gall formations there.

6. *Paspalum scrobiculatum* (wild variety)—known in Telugu as Neeti-Arika—is semi-aquatic and is found on *bunds* in paddy fields and along canal banks. At Samalkota, this grass exibited long silver-shoots, but as the parasitization was severe flies could not be reared out. At Coimbatore and in the Bellary District this grass did not exhibit galls.

7. *Andropogon annulatus.* This grass is very common along roads in black soils in the Bellary District; being perennial, it forms fairly large clumps. On close examination a good many of the clumps showed, in September 1916, long and slender galls among the fresh shoots emerging from the root-stock. Four specimens of the flies[1] were reared from these galls. Similar formations were noted also at Samalkota on this grass.

8. *Andropogon schœnanthus.* At Pattikonda, Kurnool District, old but genuine galls were noted on side-shoots high up on the stems of this grass. In November 1916, numerous examples of gall-formations in this grass were noted at Coimbatore. It is usually found growing abundantly among prickly pear bushes and in open pasture ground. The galls may appear high up on the plant in the side-shoots or may emerge directly from the root-stock. Flies have been reared. The female fly is comparatively large in size and pale pinkish-brown in colour.

9. *Andropogon pertusus.* This grass is extremely common in the pasture grounds of the Central Farm, Coimbatore. On careful examination, small-sized galls were found in small numbers on these plants. The fly, which has been reared out, resembles the gall-fly on *Andropogon schœnanthus* in general appearance, but is smaller in size.

10. *Apluda varia.* This is a slender red-stemmed, tall-growing grass commonly found among prickly pear bushes and along the banks of water-courses and canals. Galls were first noted in this grass at Samalkota in October 1916, but flies could not be reared. In November, galls were found abundantly on this grass at Coimbatore. They are slender, elongate structures of violet-brown colour and generally covered with a whitish bloom. The tip is surmounted usually by an undeveloped leaf. In some cases flower buds in the ear-heads were found transformed into galls. The fly is slightly smaller, slenderer, and darker than the one reared from *A. schœnanthus.* These galls were also found at the foot of the Nilgiris at Kallar.

[1] The flies have been named by Prof. Felt as *Dyodiplosis andropogonis.*

11-13. *Iseilema* spp. A few galls were noted on *Iseilema anthephoroides* at Pattikonda, Kurnool District, in September 1916. Flies not reared. Old galls were noted at Samalkota on *Iseilema laxum*. At Palur, S. Arcot District, a few galls were found on a grass very like *Iseilema*, but which could not be identified on account of the inflorescence not having been found. Two flies were reared, of which one has been sent for identification.

14. *Ophiurus corymbosus*. A tall erect grass with brittle stems, growing in thick clumps in moist depressions at Pattikonda, Kurnool District. Galls were found in side shoots arising from the collar region and sometimes higher up the stem. Young shoots coming up from the underground stems were also infested and showed specially thick and stout formations. Flies were not reared.

15. *Oryza sativa* (wild paddy). This was found growing luxuriantly in depressions along the railway line at Samalkota. Silver-shoots were common, but flies could not be reared out owing to heavy parasitization.

16. *Ischæmum pilosum*. The road from Adoni to Siruguppa traverses a vast stretch of undulating black soil country. The fields of indifferent cultivators in these black soils are generally infested with "Kundara gaddi" (Telugu)—*Ischæmum pilosum*—a grass with a system of spreading under-ground stems—proving as bad a weed as "Hariali" (*Cynodon*) or Nutgrass (*Cyperus*). Here and there in the midst of large patches of this grass, stiff, stout shoots of bright pink colour 4 to 6 inches long, were noted in September 1916 standing out from the surface of the ground. They ended bluntly, and in most of them the empty pupal skin of a fly was borne at the tip, from which circumstance their true nature was easily recognized. These are in all probability the very galls described by Mr. L. A. Boodle in *Kew Bulletin* No. 3 of 1910 in an article on "Galls on an Indian Grass." The galls described therein were reported to have been collected by Mr. Talbot, a Forest Officer at Poona. From the material then available, *viz.*, the pupal skins and specimens of young larvæ, Professor Kieffer described the fly *as *Oligotrophus ischæmi*, n. sp. I am not aware if the adult flies have been reared and described. In September, 1916, while examining the galls, I had the rare luck of securing two freshly emerged female specimens and one of the male. Two more were also reared out from galls. The females are rather large, black flies with an immense abdomen and short piceous wings. The males are also black but much smaller. The females were, on account of their wings being short, unable to fly. Eggs

* Prof. Felt has identified it as *Hormomyia ischæmi*, Kief.

were readily laid in tubes and hatched in three days. This fly seems to breed only in the rains, and how it passes the long dry season in these arid plains is a mystery. Possibly the young larvæ remain quiescent in the nascent buds underground and develop when the latter shoot out after the rains.

The above grasses are the only ones in which I have noted these gall-formations, but I am sure the number will be doubled or even trebled if the subject be systematically taken up and worked out.

There are some general factors governing these gall flies even in the matter of parasitization. The parasites attacking the gall maggots may be divided into two distinct classes: (1) A group, the members of which parasitize the grown-up maggot or the pupa. The mother parasite seeks the gall and inserts its eggs inside with its ovipositor, the grubs that hatch out attack and feed on the maggot or the pupa which is usually previously paralysed by the mother wasp. Coming under this group are several parasites belonging to two or three families of the super-family Chalcidoidea. (2) A second group which parasitizes the eggs. The parasites coming under this group are Proctotrupids. The adult wasp hunts out the eggs of the Cecidomyiad and deposits one or more eggs into each egg. The egg thus parasitized hatches normally into a maggot which searches for and enters the terminal buds of shoots and therein feeds and grows.

In the case of one of the parasites, *Platygaster oryzæ*, several eggs seem to be deposited in a single Cecidomyiad egg, and when the gall maggot becomes full-grown the parasite larvæ (20 to 30 in number) also grow up feeding on the internal tissues of the host. Ultimately the maggot is reduced to an empty bag, inside which the parasite larvæ spin tiny oval cocoons and pupate. *Platygaster oryzæ* is a black species common in galls on paddy, *Panicum*, etc., in most of the paddy areas. In the Bellary and Kurnool districts a yellow brown species of *Platygaster* was common in the galls of various grasses such as *Ischæmum*, *Ophiurus*, *Andropogon*, etc.

In the case of a third Proctotrupid only a single egg is apparently laid in each Cecidomyiad egg. The parasite larva kills the maggot when about half-grown, shoves off its excrement and the remnants of the internal tissues of the host into a corner of the hollow skin and pupates inside in a cocoon. This Proctotrupid is a black species about twice as large as *Platygaster*.

The above notes are mainly the result of stray observations made when opportunities occurred, and are confessedly imperfect in a good

many details, and I shall be amply repaid if this paper would induce workers to take interest in this obscure group and fill up the many lacunæ that are at present perceptible in our knowledge of galls on Indian grasses.

[Y. Ramachandra Rao; *Journal and Proceedings, Asiatic Society of Bengal (New Series)*, Vol. XIII, No. 5, 1917.]

157. Early stages of Plecia fulvicollis.

About three hundred fly maggots were found at Pusa on 4th October 1915, congregated together on the earth at the base of a Gular tree (*Ficus glomerata*). They were moving slowly in a body and appeared like a moving lump of earth.

When placed on earth in the Insectary they burrowed in at once and the adult flies emerged on 13th-15th October and proved to be *Plecia fulvicollis*, Fb., which is described in Brunetti's "Fauna" volume on Diptera Nematocera (pp. 163-164, t. 12, ff. 12, 15). The appearance of the larvæ, pupæ and adult flies is shown in the figures. (Pusa Insectary.)

158. New Indian Mosquitos.

In the *Bulletin of Entomological Research*, Vol. VI, Part 4 (February 1916), Mr. F. W. Edwards has described two new mosquitos from India. They are :—

(1) *Ochlerotatus oreophilus* (p. 357), from Gharia in the Murree Hills. This is perhaps most nearly allied to *O. pulchriventer*, Giles, also from the Himalayan region.

(2) *Culex nilgiricus* (pp. 358-359, fig. of male genitalia), from Utakamand (Ootacamund) in the Nilgiri Hills in December.

The occurrence of *Culex mimeticus*, Noé, at Utakamand is also noted in this paper.

159. Adisura atkinsoni.

Hampson's description. "Head, thorax, and forewing ochreous, the last with a greyish tinge, the costal and outer areas pinkish; the orbicular and reniform stigmata represented by indistinct dark patches; an indistinct postmedial series of specks. Abdomen and hindwing straw-yellow, the latter with the outer area more or less broadly and completely suffused with fuscous. Underside usually with the reniform prominently black."

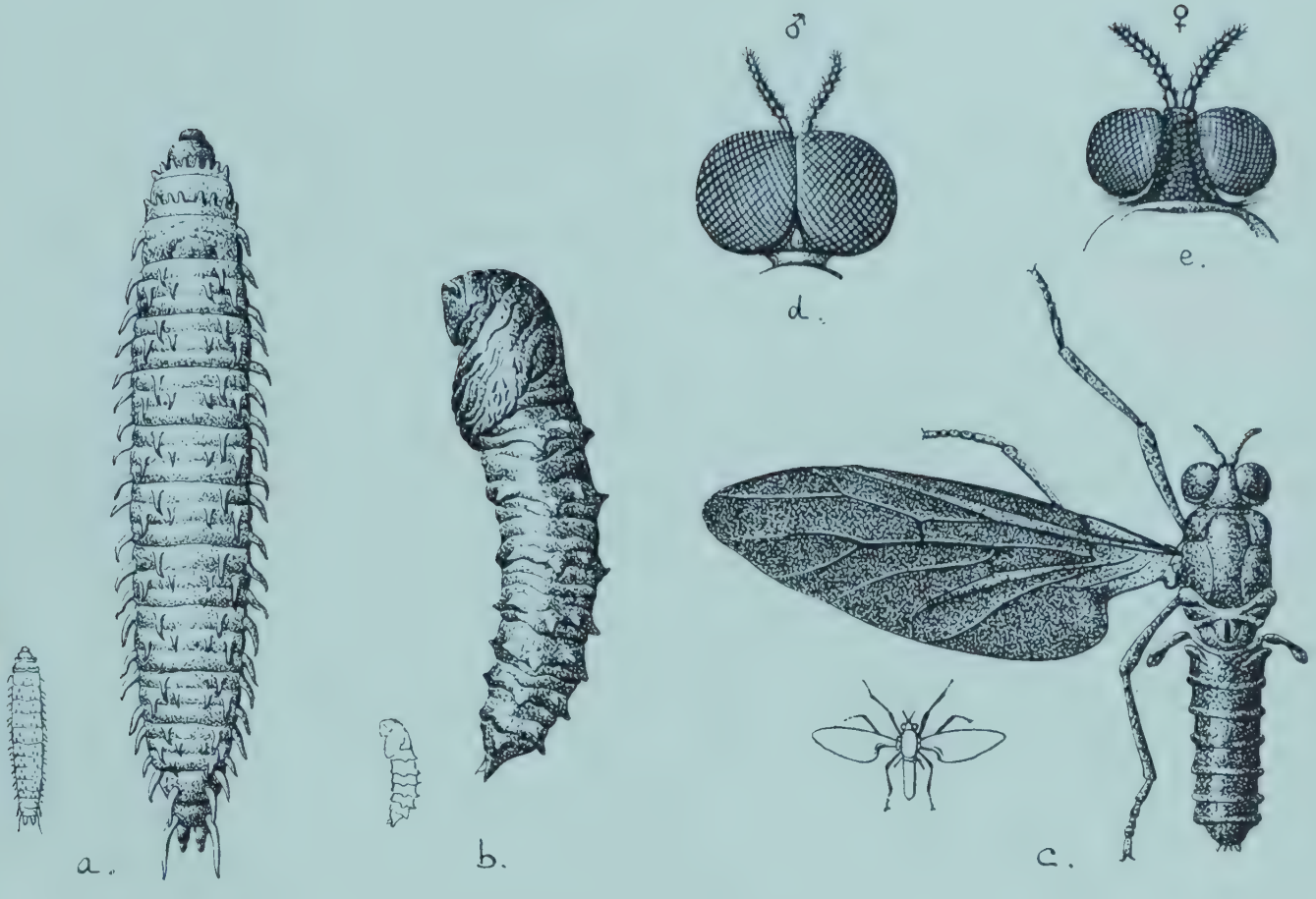


Fig. 33. *Plecia fulvicollis.*
a, Larva, natural size, and magnified (× 4).
b, Pupa „ „ „ „
c, Imago „ „ „ „
d, Head of male imago (× 11).
e, Head of female imago (× 11).

According to Hampson, its distribution has been noted to be Sikkim, Nagas, Karachi, throughout Bombay and Madras Presidencies and Ceylon.

It has been noted as a pest of *Dolichos lablab* almost throughout the Madras Presidency. In addition to *lablab* it attacks red gram to a small extent.

Eggs. The beautiful opalescent white spherical eggs are laid singly either on the pods or on the flower buds. Each egg is about ½ mm. in diameter and is attached by a slightly flattened base to the pod by a gummy secretion. At the distal end there is a depression from which numerous longitudinal ribs radiate out towards the proximal face. The egg is beautifully sculptured.

The eggs turn a dull pale brown on the second day and an orange brown on the third. They seem to hatch in three days.

Caterpillar. The young caterpillar is about 2 mm. long, elongate and slender; light green. The head is shiny black and the prothoracic shield dark brown. The meso- and meta-thoracic segments carry a transverse row of small black tubercles disposed in two rows. The anal segment is dark-brown and bears a large chitinous plate; legs and prolegs are normal.

Soon after hatching the young caterpillar devours the eggshell. It then bites its way through to an interior of the pod and proceeds to feed on the tender seed.

In about 24 hours, the carterpillar may be noticed to have assumed a greenish yellow or light yellowish orange colour; at the same time a dorso-median streak of light orange as well as lateral stripes of the same colour is observable.

The *first moult* is undergone in about two days after hatching. *The larva of the second instar* is 5 mm. long, stouter, pale green with light orange stripes. The head is light brown, the prothoracic shield also light brown, but with dark dots carrying setæ.

A dorso-median orange streak on trunk and a lateral stripe of similar colour enclosing the row of spiracles.

Two days later the *second moult* is undergone.

The third instar larva is about 10 mm. in length.

Head is light brown, prothoracic shield is also light brown and carries a pair of dorso-lateral grey streaks which are continuous with the greyish streak on the trunk extending to the hind end of the body.

Trunk : light green : middorsally there is a dark-green streak bounded on each side by a greyish green stripe.

Laterally is to be found a rather interrupted faint orange stripe bounded below by a rather pronounced grey longitudinal streak. Ventral surface dark green : prolegs dark-brown.

Tubercles are not very prominent.

The *third moult* is undergone within the next 48 hours.

The fourth instar larva is 11-13 mm. in length. Head light green : the prothoracic shield large, flat, shiny, light green with a few warts carrying setæ and marked by a faint dark brown dorso-median and a pair of dorso-lateral grey stripes. It partially covers the head somewhat like a hood.

Trunk : dorsally greyish green with a dark-green median stripe. Laterally and ventrally dark-green with a greyish orange stripe extending along the side from prothorax to hind end. The spiracles which are oval and brown edged are to be found near the upper edge of the stripe.

On the eighth abdominal segment, the lateral dark green stripe bulges out dorsally and tends to meet its fellow of the other side.

Legs and pro-legs light green.

The fourth moult occurs two days later.

The caterpillar measures 20 mm. ; stouter ; light green with darker markings.

Head, light yellowish green and shiny.

Prothoracic shield, shiny darker brown with a conspicuous grey streak on each side.

Trunk light green with a darker dorso-median streak. Dorso-laterally a faint dark brown stripe which generally breaks up into a series of conspicuous oblique brown patches of which the one on the eighth abdominal segment is the largest and almost meets its fellow over the back.

Laterally, below the above the stripe is a pale grey green stripe in the upper part of which the line of spiracles is situate. Each spiracle is surrounded by a patch of orange brown. Hairs are short and inconspicuous.

A full grown caterpillar may measure about 23 mm. This caterpillar may be easily distinguished from *Chloridea obsoleta* which also feeds on *lablab* and red gram, by its comparatively smoother skin and its habit of entering bodily into the pods. It is capable of doing much damage, a single caterpillar being capable of attacking several pods in succession. In about four to six days after the fourth moult, the caterpillar deserts the pod for the soil, prepares an oval, earthen chamber underground, and pupates. The pupa is about 18 mm. long, somewhat

thickset, red brown and of the normal Noctuid shape. The moth may emerge in about eleven days after pupation.

Life-cycle.

Egg laid on	Egg hatched on	I M	II M	III M	IV M	Pupated on	Moth emerged on
	1915	1915	1915	1915	1915	1915	1915
1. ?	26—27 Jan.	28—29 Jan.	30 Jan. 1 p. m.	1 Feb. 8 a. m.	3 Apl.	8 Feb. 10 a. m.	19—20 Feb.
2. Probably laid on 3. 11—12 Jan. 1915.	14—15 Jan.	16—17 Jan.	18—19 Jan.	20—21 Jan.	22—23 Jan.	28—29 Jan.	8—9 Feb.
4. Probably laid on 11—12 Jan. 1915.	14—15 Jan.	16—17 Jan.	18—19 Jan.	19—20 Jan.	22—23 Jan.	28—29 Jan.	8—9 Feb.
5. ?	13—14 Jan.	15—16 Jan.	18—19 Jan.	20—21 Jan.	22—23 Jan.	28—29 Jan.	8—9 Feb.
6. Probably laid on ,	28—29 Jan.	31 Jan. 1 Feb.	2 Feb. 3 p. m.	3—4 Feb.	5—6 Feb.	9—10 Feb.	20—21 Feb.

Out of a number of caterpillars collected on 21st January 1914 most pupated by the 28th January 1914. Of these only about a dozen moths emerged between the 8th and 14th February. The rest of the pupæ remained alive in the soil at the bottom of the cage throughout the period from February to November and emerged one by one between the 30th October 1914 and the 16th December 1914. This clearly shows that the moth is one that breeds only in the cold season—presumably following the habits of *lablab* and red gram which produce pods only in the cold weather.

Parasites. The caterpillar is kept in check by a yellowish Bracon (*Rhogas* ?). As many as 10 or 12 are found attacking the same caterpillar and construct their whitish oval cocoons in the interior of the pods. This Bracon is itself attacked by a black Chalcid hyperparasite.

Y. Ramachandra Rao.

160. Further Note on Adisura atkinsoni.

A caterpillar of *Adisura atkinsoni* was found at Pusa on 3rd May 1912 on *Blumea* sp. leaves by A. Mujtaba and was at first supposed to be a larva of *Heliothis obsoleta* from its general appearance. It was

about 10 mm. long, tapering slightly posteriorly, in colour yellowish-green with a mid-dorsal and lateral dark longitudinal line, the whole body covered with thick scale-like hairs. There were also longer hairs, some black-tipped and others white. The larva pupated on 4th May and the moth emerged on 13th May 1912.

A. Mujtaba. (Cage-slip 88.)

161. Early stages of Polytela orientalis.

Several caterpillars of *Polytela orientalis* were found on 1st May 1916 walking over sparse grass over almost bare rocks at Cherat, North-West Frontier Province. The caterpillar is brick-red at either extremity, white on first six and anterior half of seventh abdominal segments and banded with black as shown in the figure. The larvæ pupated in mud cells and two moths emerged at Pusa on 1st July1916, whilst two other pupæ lay over and emerged on 30th June 1917.

This moth has been recorded from Aden and the Nilgiris, and I have seen a specimen from Bellary. It has not been noted from Northern India before so far as I know. Sir George Hampson gives the food-plant as *Pancratium*.

T. Bainbrigge Fletcher.

162. Early stages of Eublemma dimidialis.

Eublemma dimidialis, Fb. (*hemirhoda*, Wlk.) has been reared at Pusa in June 1911 from pods, and in August 1917 from flower-buds, flowers and pods of *mung* (*Phaseolus mungo*), to which crop this insect may at times do serious damage, usually in association with other lepidopterous larvæ, such as those of *Catochrysops cnejus*, *Eucosma melanaula* and *Anarsia ephippias*. The larva bores into the flower-buds, flowers and seed-pods and eats out their contents. It lives in concealment, in the case of flowers tying them together with silk and living within the tied mass and, in the case of pods, entering them by gnawing a hole near the base of the pod and devouring the seeds inside, the hole being covered with a loose silken network on which the frass is extended and collects.

The full-grown larva is about 18 to 20 mm. long and 3 mm. broad across the fifth abdominal segment, tapering thence slightly to either extremity, cylindrical, segments distinct, pale greenish-yellow, the dorsal vessel showing through the skin as a broad dark stripe; head shiny dark-brown, almost black; prothorax pinkish or reddish, with a large shield which is concolorous with head, divided medially and rounded posteriorly; other segments with large brownish patches disposed to form

EXPLANATION OF FIGS. 34 AND 35.

Fig. 34. *Polytela orentalis.*

a, Larva, natural size, and magnified (× 3).
b, Pupa, „ „ „ „
c, Imago, „ „ „ „

Fig. 35. *Eublemma dimidialis.*

a, Larva, natural size, and magnified (× 5).
b, Pupa, „ „ „ „
c, Details of anal extremity of pupa, posterior view.
d, Imago, resting position, natural size, and magnified (× 5).
e, Imago, natural size, and magnified (× 5).

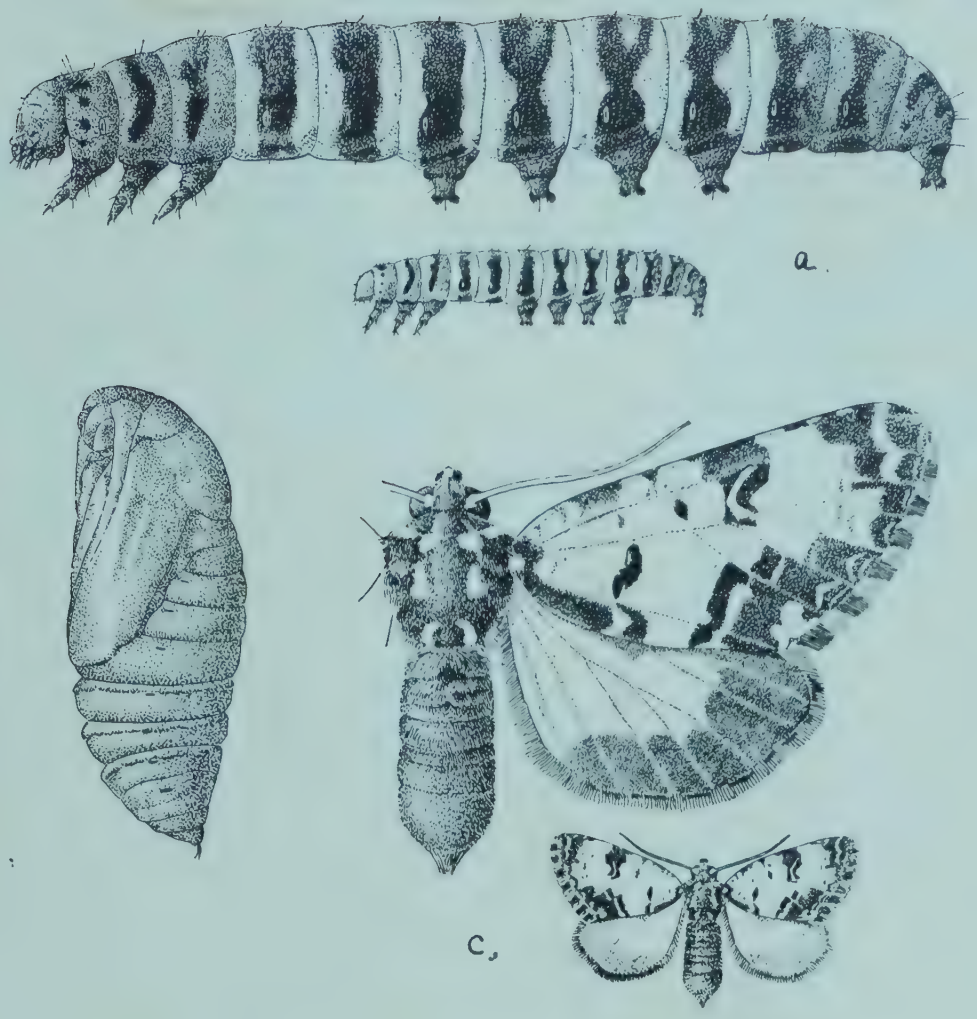


Fig. 34. *Polytela orientalis.*

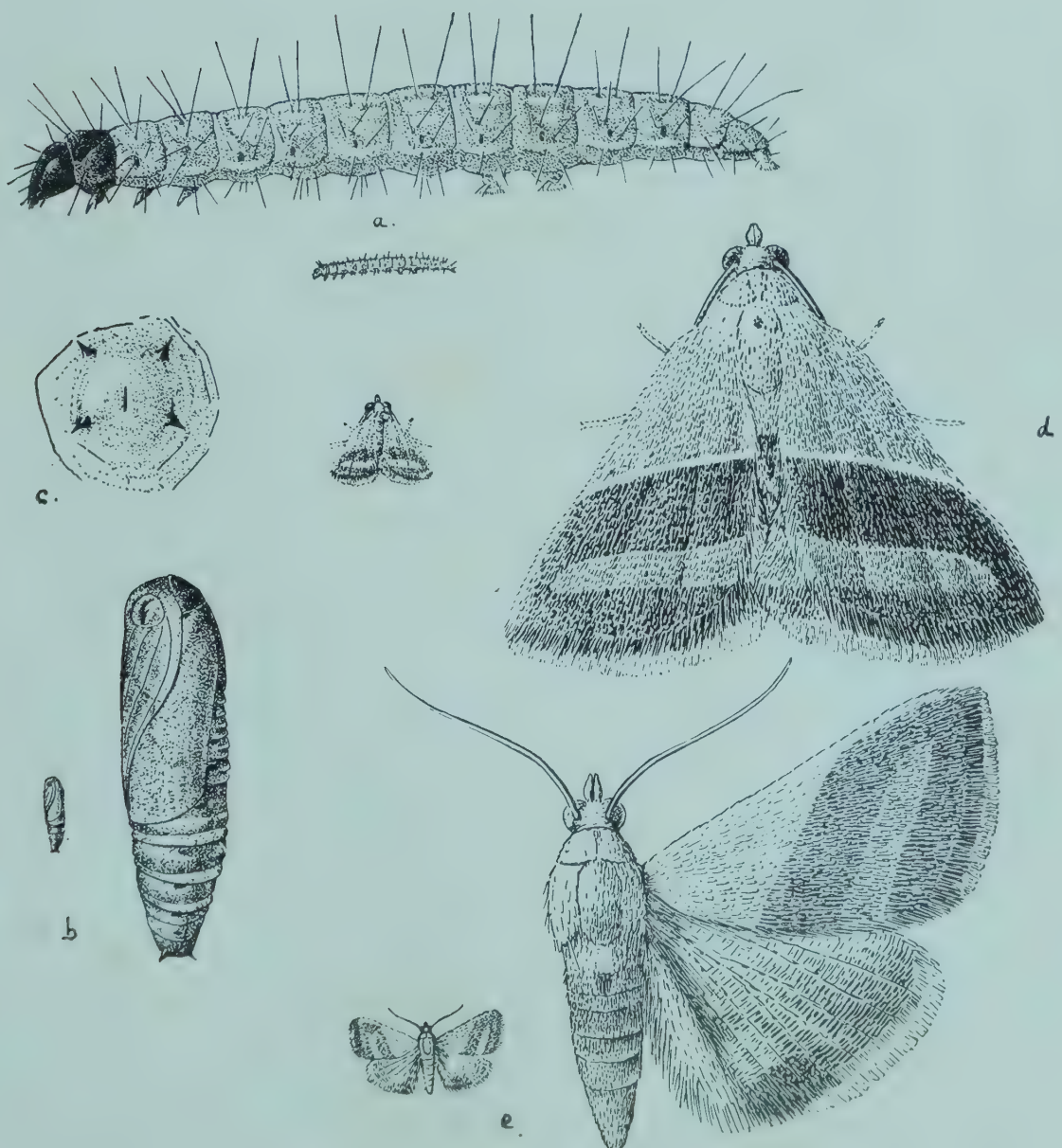


Fig. 35. *Eublemma dimidialis.*

Fig. 36. *Symitha nolalella.*

a, Spray of *Lagerstræmia flos-reginæ*, showing one leaf spun up and eaten by larvæ, on another leaf four cocoons.
b, Larva, natural size, and magnified (× 4).
c, Cocoon, dorsal view, natural size, and magnified (× 4).
d, „ lateral view (× 4).
e, Pupa, natural size, and magnified (× 4).
f, Imago, „ „ „ „

three interrupted faint lateral stripes; primary hairs very long; spiracles oval, brown; legs blackish; first and second pairs of prolegs absent.

Pupation takes place with an elongated oval silken cocoon formed in any convenient shelter, *e.g.*, amongst flowers, within a rolled leaf, or between two pods. The pupal period is about seven to eleven days. The pupa is not extruded from the cocoon on emergence.

The pupa is about 9 mm. long, moderately stout, brown, anal extremity blunt and rounded at apex and provided with four hook-like processes arranged subapically at almost regular intervals.

Pusa Insectary (Cage-slips 904, 1649).

163. Figures of early stages of Symitha nolalella.

In July 1917 larvæ of *Symitha nolalella*, Wlk., were found at Pusa damaging *Lagerstræmia flos-reginæ* by spinning together and eating the leaves. The figures show the stages in sufficient detail but no descriptions of them appear to have been made.

Pusa Insectary (Cage-slip 1624).

164. Early stages of Giaura sceptica.

Giaura (*Cletthara*) *sceptica*, Swinh., has been recorded as a sporadic minor pest of soy-bean (*Glycine hispida*) and velvet bean at Surat and Pusa, the larva rolling or tying the leaves, especially the lower leaves, and eating holes in them.

The larva is about 15 mm. long and 2·5 mm. broad across the posterior portion of the body, which tapers very slightly anteriorly, cylindrical, yellowish green, segments distinct, skin on intersegmental regions slightly folded and giving the appearance of a yellowish band, all segments with a network of whitish markings; prolegs equally developed. Before pupation the larva turns reddish or coppery-brown with faint whitish lateral markings which combine along the subdorsal region to form a stripe.

Pupation takes place either on a leaf within a silken cocoon much like that of *Earias fabia* or underground in earthern cells. The pupal period is eight to ten days.

The pupa is 9 to 10 mm. long and 4 mm. across thoracic region, thence gradually tapering posteriorly, both extremities rounded, brown, darker dorsally, with a coating of white bloom all over; anal segment with a ring of short posteriorly-directed spines.

Pusa Insectary (Cage-slip 1659),

165. Protective device in pupa of Eligma narcissus.

Eligma narcissus is abundant at Coimbatore and the larvæ often defoliate small trees of *Ailanthus excelsa* in November and December. When full-fed, they pupate on the stem of this tree, the pupa being enclosed in a long boat-shaped cocoon of greyish silk which exactly matches the colour of the bark. These cocoons are often grouped in masses on the stems, the larvæ apparently preferring to pupate more or less gregariously.

When disturbed, the enclosed pupa is able to make a loud rattling sound which is evidently of protective value and would probably serve to daunt any small vertebrate enemy attacking the cocoon. On examination of the pupa and cocoon it is seen that this sound is produced by the friction produced by rapid vibration of the anal extremity of the pupa against several strong longitudinal ridges of silk towards the anal extremity of the cocoon, so placed that these ridges are opposite to and are acted on by a series of short longitudinal chitinous ridges on the dorsal surface of the anal segment of the pupa. It will be noted from the figures given here that the three posterior segments of the pupa are considerably reduced in size in comparison with the preceding segments, and this reduction admits of a very considerable amount of lateral movement when these posterior segments are vibrated laterally, thus bringing the pupal ridges into strong contact with the silken ridges on the inner surface of the cocoon.

T. Bainbrigge Fletcher.

166. A new foodplant of the Castor Semilooper, Achaea janata.

Achœa janata (*Ophiusa melicerta*), which is often a serious pest of castor all over South India, has so far been noted to feed commonly on castor, pomegranate and *Euphorbia pilulifera*. It has also been noted as feeding on *Sapium sebiferum* and tea in Dehra Dun (*Indian Museum Notes*, Vol. III, 3, page 3). Very recently, however, Mr. Latham, the District Forest Officer of Salem, in forwarding specimens of this insect has remarked that he noted the larva feeding on *Albizzia amara* in October 1914 in the Salem District. I think there is no record of this foodplant and is therefore worth noting.

T. V. Ramakrishna Ayyar.

167. Early stages of Rivula bioculalis.

Larvæ of *Rivula bioculalis*, Mo., have been found at Pusa feeding on *Panicum* sp., but not hitherto in injurious numbers. The larvæ are

EXPLANATION OF FIGS. 37 AND 38.

Fig. 37. *Ginura sceptica.*

a, Larva. natural size, and magnified (× 5).
b, Cocoon, „ „ „ „
c, Pupa, „ „ „
d, Imago, „ „ „ „

Fig. 38. *Eligma narcissus.*

a, Pupa, after emergence of imago. (× 4).
b, Cocoon, interior surface, (× 2).
c, Portion of interior surface of cocoon, more highly magnified, to show details of silk ridges, (× 8).
d, Anal segment of pupa, more highly magnified, to show stridulating apparatus. (× 16).

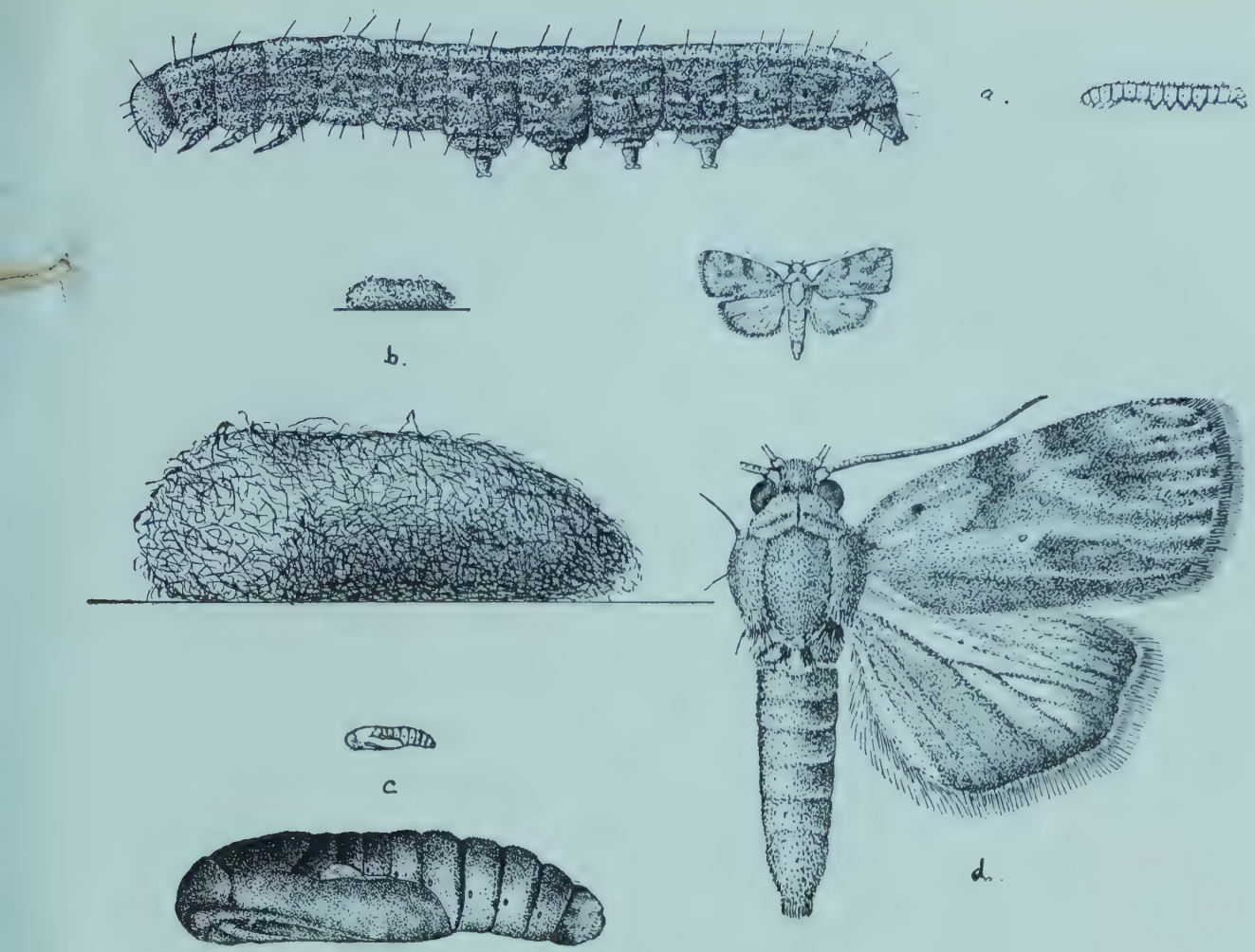


Fig. 37. *Giaura sceptica.*

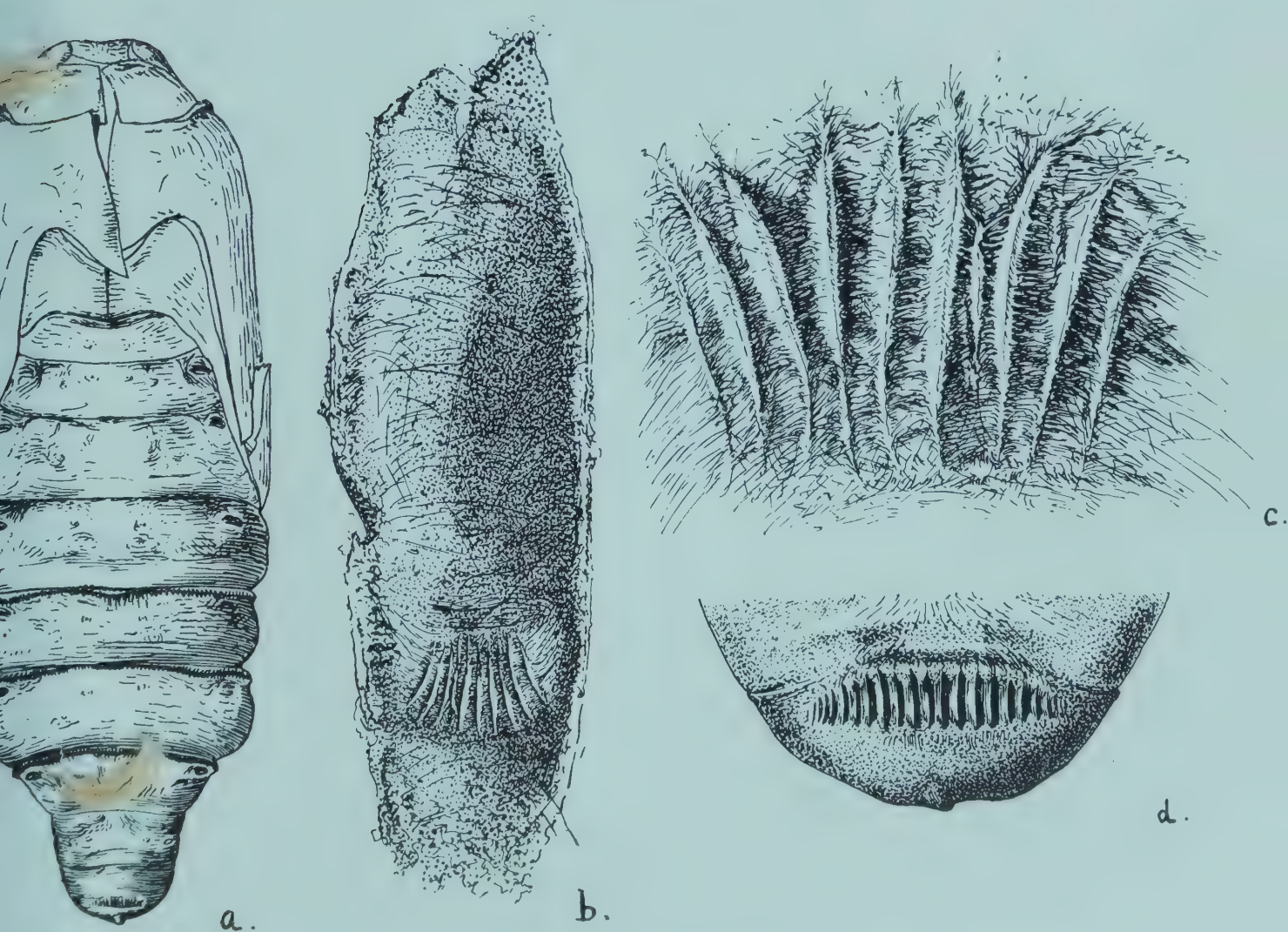


Fig. 38. *Eligma narcissus.*

found on the leaves, which are eaten from the edge inwards. Larvæ found on 15th August 1917 pupated on 18th and 22nd August, the moths emerging on 22nd and 29th August 1917.

The larva, when about 12 mm. long, is about 1·75 mm. broad, cylindrical, tapering very slightly towards either extremity, green with an interrupted white subdorsal stripe, the dorsal vessel showing through the skin as a dark green stripe; head larger than following segments, rounded, pale-yellow with a greenish tinge and minutely speckled with grey, the grey specks arranged in groups; primary hairs long; prolegs slender, equally developed. The full-grown larva measures about 17 mm.

Pupation takes place on a *Panicum* blade, which is slightly rolled, in a flimsy open cocoon formed by a few transverse silken threads.

The pupa is about 13 mm. long, cylindrical; head rounded, remainder of body tapering posteriorly almost to a point; cremastral hooks entangled in silken cocoon.

Pusa Insectary (Cage-slip 1650).

168. Larva of Lyncestis amphix.

Figure 306 on page 446 of *Indian Insect Life* represents a larva described as that of an *Euscotia* sp. and on page 447 this is referred to as an "apparently undescribed species or variety" of Cucullianæ. This species has now been identified as *Lyncestis amphix*, Cr. (*Faun. Ind., Moths*, II, 479, f. 267) and the necessary corrections should be made.

169. Ophideres ancilla and Ophideres materna.

The caterpillars of *Ophideres ancilla* were found at Coimbatore in November 1914 feeding on the leaves of *Achæranthes aspera*—a common amaranth weed at Coimbatore. They are semiloopers of large size—nearly 2½ in. in length. In colouration they are a beautiful velvety black with blue specks and with 2 pairs of conspicuous eyelike markings in white and blue on the 3rd and 4th abdominal segments and a pair of large yellow patches on the second segment. There are only four pairs of prolegs—the first pair being absent. A dorsal protuberance is present on the last abdominal segment. The pupa is large and thickset with a dorso-median keel in the thoracic region. It is dark brown with a remarkable golden sheen all over. The abdominal segments are coarsely pitted.

The moth emerged on the 13th day after pupation.

The moth has the forewings brown with an elongate median green patch and the hindwings orange with a crescent-shaped marking and a submarginal patch of black colour.

The caterpillars of *Ophideres materna* were observed feeding on a wild convolvulus creeper in the Farm at Coimbatore in October-November 1914 and 1915. They were of a light grey brown colour with a soft velvety look. There were numerous yellow, orange and blue speckles distributed over the body. Only two pairs of ocelli were present—located on the third and fourth abdominal segments. The ocelli had the iris partly yellow and partly orange and the pupil blue. The first pair of prolegs is absent as in *ancilla*: a dorsal protuberance on the anal segment. When disturbed the caterpillar doubles up the anterior half of its body and lifts up the hinder part so as to form an irregular S in outline. In this posture the body rests wholly on the first three pairs of prolegs, and the ocelli are brought into prominence. *Ophideres ancilla* has similar habits.

The pupa is thickset and large, nearly one inch in length, dark reddish brown, smooth but without any particular golden lustre as in *ancilla*. The thorax is smooth without any keel. The abdominal segments are also smooth and very finely and minutely pitted.

The moth emerged in 14 days. Forewings greyish green with numerous striæ of brown colour. A silvery Y-shaped mark along the middle of the wing. Hindwing orange with a round black spot and a marginal black band.

Y. Ramachandra Rao.

170. Ophideres cajeta a distinct species.

In the *Fauna of India, Moths,* Volume II, page 560, Sir George Hampson sinks *Phalæna cajeta,* Cramer, as a synonym of *O. fullonica,* Linn., although Moore, in his monograph on the Ophiderinæ of the Indian Region (*Trans. Zool. Soc.*, XI, 67) had treated *cajeta* as distinct from *fullonica.* Examination of Moore's description and figures of *cajeta,* in conjunction with a series consisting of one male and six females from South Malabar, sent from the Forest Institute at Dehra Dun for identification, leave no doubt in my mind as to the distinctness of *cajeta* as a species. It is uniformly smaller than *fullonica*; the outer margin of the forewing in *cajeta* ♂ is straighter, whilst in *fullonica* ♂ this shows a tendency towards slight crenulation; and in the female the forewing in *cajeta* is of a much more uniform mottled brown without the strong contrasts seen in *fullonica.*

T. Bainbrigge Fletcher,

171. An alternative foodplant of Hyblaea puera.

In September-October last we had a plague of caterpillars of the Noctuid *Hyblæa puera*, Cr., on the Agricultural College Farm, Coimbatore. The plant that suffered most was *Millingtonia*. There are a number of these young trees in various parts of the estate and not one escaped from a serious attack; and those plants that shared in the damage, though to a smaller extent, were *Bignonia megapotanica*, and *Vitex negundo*, L. Hole in his interesting paper on this insect (p. 685, Vol. XV, *Bombay Journal*) mentions teak, *Millingtonia* and Bignoniaceæ as foodplants, and has not mentioned anything regarding *Vitex negundo*, L., which is one of the Verbenaceæ. This is apparently an alternate foodplant of the pest not recorded till now; regular hand-picking of the folded leaves containing the larva and spraying with lead arsenate checked the pest. It may also be stated here that a number of Tachinid flies were reared out as parasites from *Hyblæa* larva. This fact of the existence of a dipterous natural enemy has not been noted by Hole among the enemies he has mentioned in the above paper.

T. V. Ramakrishna Ayyar.

172. Early stages of Rhyncolaba acteus.

A caterpillar of *Rhyncolaba acteus* was found at Pusa on 6th August 1917 eating leaves of *Pythonessa wallichii*. It spun up on 11th and pupated on 12th August and the moth emerged on 25th August.

The fullgrown larva is about 75 mm. long when fully extended and about 10 mm. broad across the abdominal region, cylindrical, the thoracic region tapering anteriorly. The general colour is green, the sides with white markings amongst which are eight (one thoracic and seven abdominal) upwardly sloping broad white stripes which, in the case of those on the abdominal segments, pass over the spiracles and at their upper ends (about the subdorsal region) are marked off as elongated oval spots. A large subdorsal ocellus on the anterior part of the first abdominal segment and partially encroaching on to the metathorax. Caudal horn short, stout, reddish, with down-curved tip. Spiracles whitish.

Pupation takes place in a slight cocoon formed under a leaf by a large-meshed silk network. Before pupation the colour of the larva changes to grey with dark patches, the oval spots turning pinkish or brick-reddish. The pupa measures 50 mm. in length from the upper part of the loop of the proboscis to the tip of the anal extremity and 46 mm. from head to tail, and is about 11 mm. broad across the

broadest portion of the abdomen. The proboscis is contained in an antero-ventral prolongation of the head, which gradually narrows and then, turning downwards and then inwards, forms a large loop thickened again towards its apex which is embedded in the surface of the prothoracic region. The anal segment is deeply concave ventrally and its dorsal surface is produced posteriorly very considerably. In colour the pupa is a dull dirty brown, the dorsal surface darker and the ventral surface of the abdomen with large whitish patches.

Pusa Insectary (Cage-slip 1655).

173. Life-history of Taragama siva.

Ovum. The egg (figures 40*a*, *b*) is almost spherical and measures 1·5 to 1·7 mm. in diameter from base to apex and 1·3 to 1·5 mm. in diameter transversely. The shell is thick, smooth, tough and moderately hard. The micropylar area is dull brown, broadly bordered with yellowish-white, and this is again surrounded by a broad dull brown band irregularly indented on its lower edge; the remainder of the surface is of a dirty yellowish-white speckled with brown. The eggs are laid horizontally in clusters or in irregular rows, the moth moving as they are deposited. Eggs laid on 17th and 18th May 1914, hatched on 24th and 25th May, the young larva gnawing away the micropylar area and the surrounding portion of the egg-shell and emerging through the hole so produced; after emergence it usually eats the greater part of the empty shell before wandering away in search of plant food.

Larva. First instar.—The newly-hatched larva (figure 40*c*) is about 5 mm. long, dorso-ventrally compressed and slightly tapering posteriorly. Head shining black, about 1 mm. across, without any hairs. Prothorax on each side with a yellow, fleshy protuberance bearing long white hairs, dorsal intervening portion dull black. Mesothorax and metathorax each with a transversely-elongated dorsal black patch. All segments from mesothorax to eighth abdominal bear on each side a flattened, fleshy, pale-yellow protuberance bearing a tuft of long white hairs. The abdominal segments are transversely wrinkled, rather dirty-whitish in colour, their interstices showing as fine black lines. The anterior trapezoidal tubercles on all segments from mesothorax to ninth abdominal are large yellow protuberances bearing tufts of long white hairs. The posterior trapezoidal tubercles are small protuberances similarly bearing tufts of long white hairs. Some of these hairs are about 5 mm. long and their presence gives the larva a hairy

EXPLANATION OF FIGS. 39 AND 40.

Fig. 39. *Rhyncolaba acteus.*

a, Larva, slightly magnified (× $1\frac{1}{6}$).
b, Pupa, „ „ „
c, Imago, „ „ „

Fig. 40. *Taragama siva.*

a, Eggs as laid on twig.
b, Egg, natural size, and enlarged (× 6).
c, Newly-hatched larva, natural size, and enlarged (× 6).
d and e, Full-grown larva, natural size.
f. Cocoon, natural size.
g, Pupa, natural size.
h, Male moth, natural size.
i, Male moth, in resting attitude.
j, Female moth, natural size.
k, Female moth, in resting attitude.

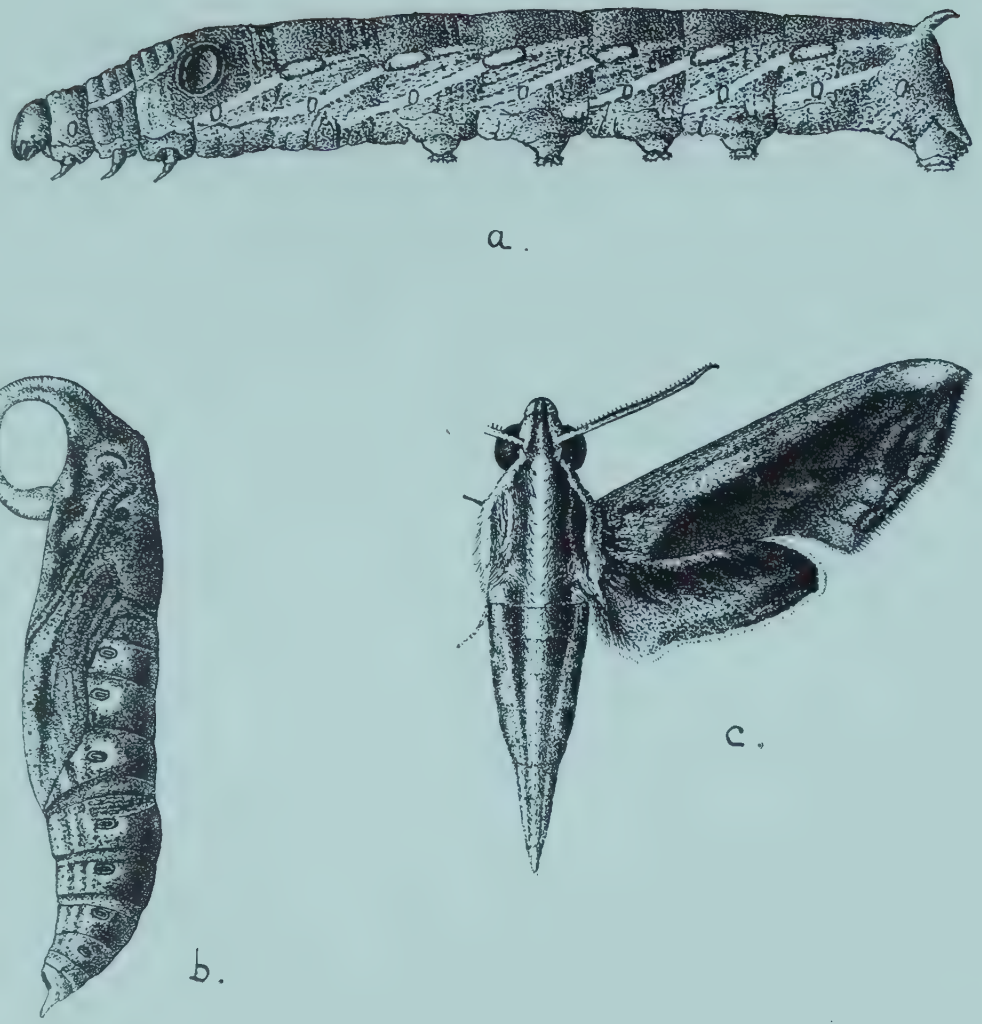


Fig. 39. *Rhyncolaba acteus.*

Fig. 40. *Taragama siva.*

appearance. The surface of the segments does not possess tufts of hairs but there are single hairs on the primary tubercles. The ventral surface and legs black, prolegs pale yellow.

Second instar.—After the first moult the larva is about 9 mm. long. The head and back of prothorax are dark grey and covered with minute white hairs, the general colour of the body being light grey. The dorsal regions of mesothorax, metathorax, and first, seventh and eighth abdominal segments are black, these blackish areas on metathorax and seventh abdominal segments coalescing with those on the next succeeding segments respectively. The mesothorax and metathorax each bear posteriorly a transverse reddish-yellow ridge having in its middle a few short yellow hair-like processes with their tops flattened. The anterior trapezoidal tubercles on mesothorax and metathorax and first and eighth abdominal segments are black, those on prothorax and ninth abdominal are grey, and the remainder reddish yellow. All tubercles bear a few long black hairs and not regular tufts. The lateral processes each bear a long black hair and also numerous whitish hairs. The dorsal surface also bears numerous whitish hairs but these are more prominent on the lateral regions of the body.

Before the second moult the larva covers a portion of the stem of its foodplant with a layer of shining silvery-white silk, and rests on this pad with its prolegs entangled in the fibres. The skin is not thrown off posteriorly in a crumpled mass but the larva walks forward out of it as from a case, the head covering being cast off separately. The cast skin is partially or wholly devoured.

Third instar.—After the second moult, the larva is about 15 mm. long and in general appearance resembles the previous instar. The black markings on meso- and meta-thorax do not ordinarily show when the larva is at rest, being enclosed and hidden in transverse folds when open and expose them when the larva moves. The black markings on seventh and eighth abdominal segments in the second instar have almost disappeared in the third, giving place to grey.

Fourth instar.—After the third moult the larva is about 25 mm. long and is little changed in general appearance. The posterior trapezoidal tubercles on first to seventh abdominal segments have become larger and are now red in colour. The anterior trapezoidals are also enlarged, that on the eighth abdominal segment being larger than the others.

Fifth instar.—After the fourth moult the larva is about 40 mm. long. Head grey, covered with grey hairs. Colour of back greyish-brown

with scattered indistinct violet spots. Anterior and posterior trapezoidals red. The tufts of grey hairs on lateral processes are denser.

The full-grown larva (figure 40*d*) is about 50 (male) to 70 mm. (female) long, moderately stout, cylindrical, tapering slightly posteriorly. When disturbed it assumes a terrifying attitude (figure 40*e*) by raising the head and thorax and displaying two tufts of short black hairs on the meso- and meta-thorax; just bordering the posterior edge of the mesothoracic fold there is also a tuft of short flat-topped violet hairs and in a similar position on the metathorax a similar but larger tuft of white hairs: in the resting position these tufts are hidden inside the transverse folds.

Pupation. When fully fed the larva prepares on a twig of the foodplant an elongated cocoon tapering toward each extremity (figure 40*f*). The cocoon is composed of brown silk into which larval hairs are interwoven and is about 35 to 45 mm. in length and 15 to 20 mm. in diameter. The last larval skin is thrust off posteriorly in a shrunken mass which lies close to the anal extremity of the pupa, the moth emerging through a slit at the anterior extremity of the cocoon, the empty pupa-case remaining inside the cocoon to which it is attached by its reddish cremastral hooks.

The pupa (figure 40*g*) is about 25 to 30 mm. long by 8 mm. in diameter, cylindrical, bluntly rounded at each extremity, dark brown with short brown hairs.

Life-cycle. The life-cycles of two individuals (both males) are shown below :—

Dates	No. 1	No. 2
Egg laid	17-18th May	17-18th May.
Egg hatched	24th May	24th May.
First moult	28th May	28th May.
Second ,,	31st May	31st May.
Third ,,	4th June	4th June.
Fourth ,,	9th June	10th June.
Formed cocoon	22nd June	21st June.
Moth emerged	3rd July	2nd July.

Foodplants. At Pusa this insect has been reared on *Tamarix gallica*, *Murraya exotica*, *Polyalthia longifolia*, rose, *Acacia arabica*, and *Zizyphus jujuba*. Of these the last two are probably the most common foodplants.

[Pusa Insectary. Cage-slips Nos. 369 and 659 and unnumbered cage-slips, dated 19th March 1910 and 17th May 1914.]

174. A new pest of the Coconut palm on the West Coast.

In December last, a communication was received regarding damage done to coconut trees by some insects in some sea-side villages in the Cochin State from the Superintendent of Agriculture of that State. Following close on this information a report was also received through the local Revenue officials from certain cultivators in the Ponnani taluq of the Malabar District describing a similar attack of a coconut pest. The localities from which these reports were received are so adjacent to each other that no doubt was entertained as to whether the pest was the same or not in both the places. Before samples of insects were received for examination, it was assumed from the information contained in the above reports regarding the nature of the damage done, that the pest might be *Parasa lepida*, Cram., an insect previously noted as attacking coconut and palmyra trees. This presumption was also strengthened by the fact that *Parasa lepida* was found doing serious damage to coconut trees in almost the same locality in Cochin eight years ago. When, however, the specimens of insects were received, it was found that the pest under consideration was quite a different one from the one previously noted, though both belong to the same group and possess the same habits.

The early reports having come late, as usual, and as it was not possible to visit the locality and make the necessary investigations, the work was postponed pending further reports. As expected, a report of a second outbreak was received from the same locality in the Ponnani taluq. The place was then visited, the local conditions were studied and some live material was brought to Coimbatore to follow the life-history of the insect in captivity. The following is a brief account of the investigations made so far in connection with this insect.

Distribution. Previous history and nature of damage. So far in South Malabar, the insect has not been found to enjoy a wide distribution as a pest. It was found confined to a small tract of land in the backwaters adjoining the sea coast and on both occasions when we had reports of this pest, they were received from this particular tract—Vadanapalle amsom in the Ponnani taluq. The local coconut cultivators

appear to know the insect; it has been noted during previous years on the coconut tree, on a very insignificant scale, nibbling the leaf tips here and there, but it was only during the last season when the insect multiplied and assumed pest proportions that it attracted the serious attention of the cultivators. The first outbreak was noted in December 1915 and the second one followed in February, and in both these cases the infestation was in the same place.

The injury done to the trees by the pest consisted in the foliage being eaten up by hundreds of these small fleshy wormlike creatures. Numbers of them remain feeding gregariously on the green epidermis of the leaves and in bad cases the coconut fronds are actually skeletonized. It has been found that the maturer leaves are affected more, while the tender portions do not suffer so much. The tree stem is immune. As between old and young trees the latter appear to be more or less free from attack. The effect of a bad attack on a tree is that the affected fronds dry up and drop down, and gradually the tree becomes very weak and suffers considerably in outturn.

The pest, its classification and description. The insect under consideration is a moth of the family Limacodidæ. The characteristic features of the members of this family are easily made out from the peculiar fleshy slug-like appearance of the larvæ of the great majority of them. This feature has given them the popular name of "slug caterpillars" and "gelatine grubs". It is this immature stage of the insect—the slug caterpillar—that is directly responsible for the damage done to coconut trees. As it is difficult to correctly identify the insect from the larval stage, except in very well-known cases, adults were bred out in captivity from the few specimens received with the earlier reports. The Imperial Entomologist to whom specimens were forwarded identified the insect as *Contheyla rotunda*, Hmp. (Fig. 41*a*, *b*). The only previous record of this insect is by Sir George Hampson in his paper on the Moths of India, page 196, Volume XVI of the *Journal of the Bombay Natural History Society* in the year 1905. It is there described as a new species and as found in Karwar, North Kanara. The following is his description of the moth : "Grey brown. Forewing with slight dark irroration, a series of black points from costa beyond middle excurved to vein six, then becoming sub-terminal. Hindwing slightly darker. Cilia of both wings yellowish at base. Wing expanse 16 mm. in the male and 20 mm. in the female."

Thus it will be seen that this is the first record of the insect *as a pest*.

Life-history. Though the main points in the life-history of the insect have been noted, it was not possible to study the various points in detail

Fig. 41*a*.

Fig. 42*a*.

Fig. 42*b*

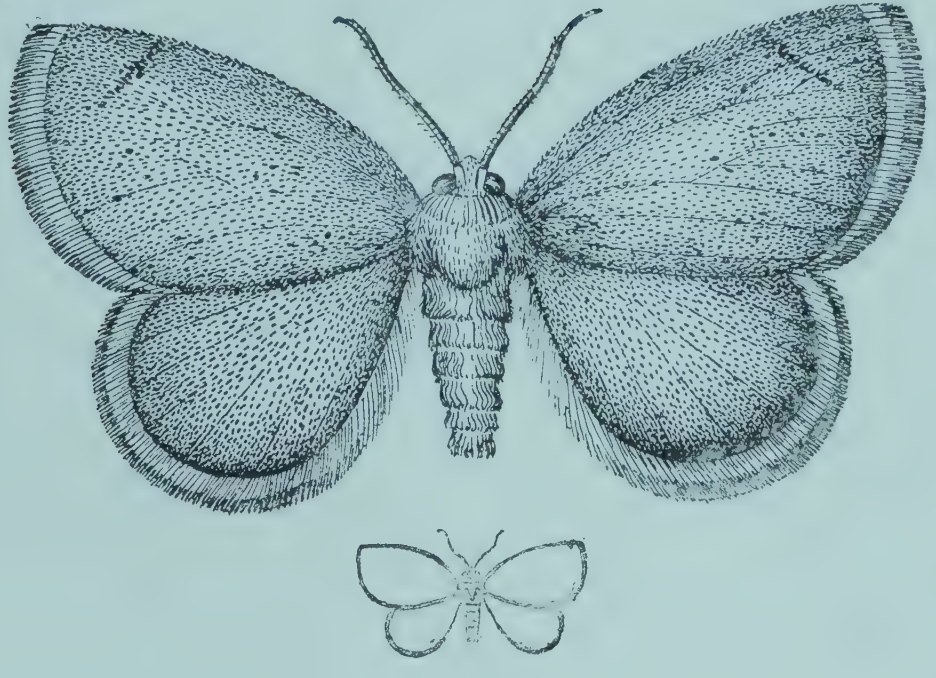


Fig. 41*b*.

Fig. 41*a*. *Contheyla rotunda*, male moth (magnified and natural size).
„ 41*b*. „ „ female „ „ „ „ „
„ 42*a*. Chalcid parasite of *Contheyla rotunda* moth (natural and magnified).
„ 42*b*. Braconid parasite of *Contheyla rotunda* moth (natural and magnified).

Fig. 44.

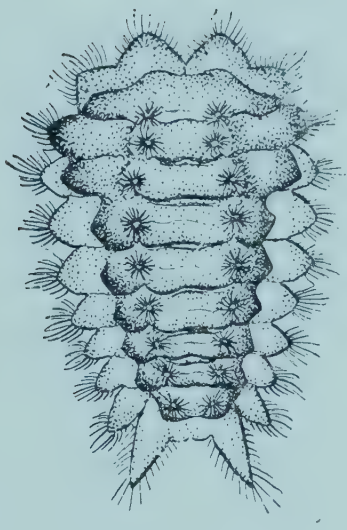


Fig. 45.

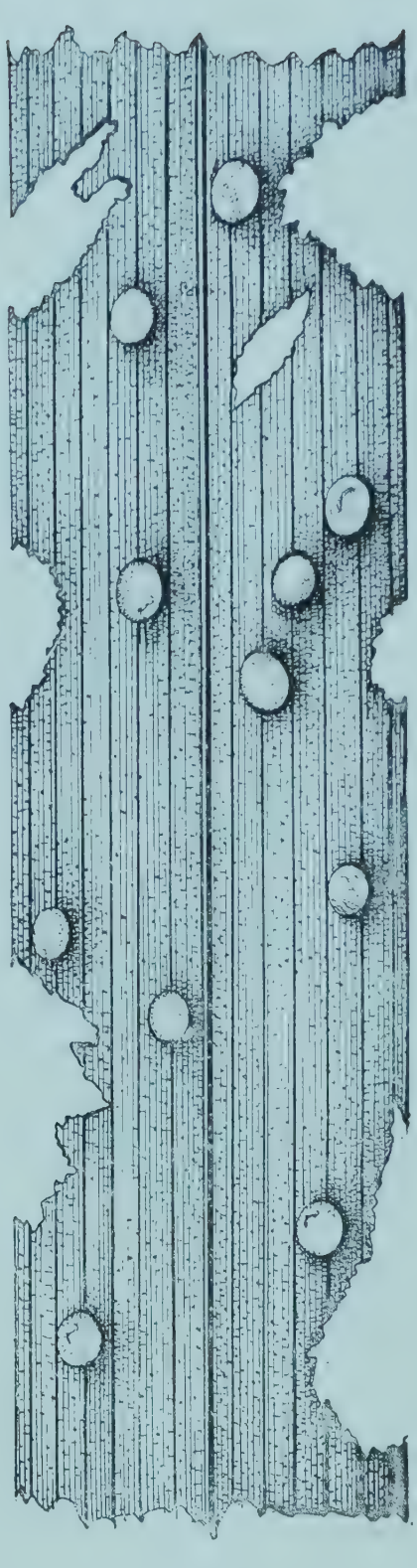


Fig. 43.

Fig. 43. Eggs of *Contheyla rotunda* on palm leaf magnified (× 2).
„ 44. „ „ „ magnified (× 12).
„ 45. Caterpillar ef *Contheyla rotunda* (natural and magnified).

during the past season. The following points have been followed so far :—

Each parent insect is capable of laying from 50 to 170 eggs. These insects are minute spherical, flattish objects resembling scales and laid in groups on the leaf surface (Fig. 43). Each is about a millimetre across the poles and has a shining, transparent, colourless, jelly-like consistency. When the hatching time approaches the embryo inside the egg is seen through the transparent egg shell. In about four days the egg hatches and the tiny larva $\frac{3}{4}$ to 1 mm. in length is soft and fleshy—quite characteristic of Limacodid larvæ. It is pale brown in colour with a number of greyish processes. These latter are disposed along the lateral edges of the body and along the median dorsal region. The head is kept concealed underneath the prothorax. The young larva feeds on the leaf by scraping the epidermis. As the larva feeds and passes moults, it grows in size and the processes become fleshy protuberances, each with a central long spine with a circlet of shorter ones around. The larvæ are very slow moving in habit ; they do not feel happy when they are mechanically transferred to fresh leaves in captivity ; due to this many of them died before reaching maturity. The full-fed larva when about to pupate constructs a small, hard, oval, dirty brown, shell-like cocoon about 4 mm. across and then changes into the chrysalis inside the cocoon. At the end of the pupation period the moth emerges out of it. The male is smaller than the female though in other respects the differences are not so clear. A generation from egg to adult roughly takes about a month and a half.

Number of broods in the year. That two reports were received from the same place, one following the other, has clearly proved that there are at least two generations passed by the pest in the year. One in December-January and the other in February-March. What the pest does during the rest of the year, how it passes its life, whether it has a resting or hibernating period, etc., are all points which remain to be investigated.

Other host plants. So far, no other plant has yet been found on which the insect is found to breed. It is not unlikely that other palms might serve as alternate foodplants.

Natural enemies. Two hymenopterous parasites have been found to be prasitic on this insect. One is a dark stout built small Chalcid and

the other a slender delicate brown Braconid wasp. These attack the larvae and lay eggs inside their bodies, and these grubs hatching out of these eggs feed on the body of the slug caterpillar and gradually kill the latter. In this way these wasps play some part as natural enemies to this pest.

Control measures. The easiest and most practicable method of checking the pest is the one which the local cultivators practise though it is done without any system. This consists in the burning off of the affected foliage. When the depredations of the insect are noted on a small scale early in the season, the systematic method of cutting away the affected fronds and burning them will prevent the multiplication of the pest during the next generation and the pest will gradually be checked.

Spraying with a stomach poison like lead arsenate was only found effective in the case of young trees which are not very tall. On the whole spraying will be found impracticable against this pest which generally attacks old trees and the fairly ripe foliage which are difficult to operate satisfactorily with a spray pump.

The pest can also be destroyed while in the cocoon stage, as these shell-like objects are clearly seen on the attacked fronds, which can be easily cut and burnt.

It might be possible to check the pest in other, and perhaps easier, ways when more is known of the insect. The following important points which still require investigation might give several clues to tackle the pest in the future :—

(*i*) The exact number of broods in the year.
(*ii*) Other alternate foodplants, if any.
(*iii*) Natural enemies other than those noted already.
(*iv*) Effect of weather changes.
(*v*) The habits of the adult insect which might help us to gauge the facilities for the distribution of the pest.

It is hoped that as opportunities offer, further investigations with this insect will be pushed on. The attached diagrams will give some idea of the different stages of the insect.

T. V. Ramakrishna Ayyar.

175. Breeding notes on Papilio polytes.

A pair of *Papilio polytes*, Linn., "in cop" was taken on the 24th November 1915, resting on a twig of *Toddalia aculeata*, a Rutaceous plant in the vicinity of the wetlands of the Central Farm, Coimbatore. The ♀

was of the *polytes* form, a mimetic of *P. aristolochiæ*. This fertilized ♀ laid 37 eggs within 24 hours after copulation, later on 9 eggs ; she succumbed in the morning of the 26th.

The egg was rounded, yellow, elastic, sometimes dotted with pale orange, laid singly, preferably on tender shoots, but also on twigs and older leaves. From the time of oviposition, no radical change in the colour of the egg was noted, until just before hatching when a black v-shaped mark was visible through a transparent shell.

Most of the eggs had hatched by the 29th morning. It was observed that the just-hatched caterpillars turned round and ate up the empty egg-shells partly. The larva measured 3·5 mm. sometime after hatching.

By the 1st December 1915 only 27 caterpillars were surviving and by the 28th only eleven. This large percentage of mortality was mostly due to the difficulty in obtaining the *Toddalia* leaves. These caterpillars would not feed on lime or sour lime leaves.

The first pupa was got by the end of December. The pupæ varied considerably in colour; some were ashy brown, others green and others grey.

Altogether only ten butterflies emerged. Six black-and-yellow males, three ♀ *polytes* form, mimetics of *Papilio aristolochiæ,* and only one ♀ *romulus* form, mimetic of *P. hector*. No *cyrus* form of ♀, similar to the ♂ emerged.

P. Susainathan,—31-III-1916.

176. Further Note on Papilio polytes.

Several attempts have been made at Pusa to rear continuous broods of *Papilio polytes* to note the relative occurrence of the polymorphic forms of the female, but various difficulties have hitherto prevented successful rearing for more than two generations and those only on a small scale. What is really required is continuous rearing of successive broods on a large scale, but for this special arrangements, in a locality more suitable than Pusa, are necessary. The following is a brief account of one experiment made at Pusa.

A female of the *polytes* form was captured at Pusa on 1st August 1917 and kept for eggs. The male parent was unknown but the female was fertilized and laid 65 eggs on the two following days. The eggs began to hatch on 5th August and the larvæ were fed on *Murraya kœnigii*. Two larvæ pupated on 17th, twelve on 18th, twenty-five on 19th and three on 20th August, all the pupæ being green. Of the

forty-two pupæ obtained, forty emerged as follows :—

Date	Male normal (*polytes*)	Male (*cyrus*)	Female (*cyrus*)	Female (*polytes*)	Total
25th August	...	1	...	...	1
26th August	3	5	1	3	12
27th August	6	...	2	4	12
28th August	1	...	1	6	8
29th August	2	...	...	1	3
30th August	...	...	...	2	2
31st August	...	...	1	1	2
Total .	12	6	5	17	40

From this F_1 brood several attempts were made to obtain eggs but, although pairing took place in several cases and eggs were laid, in all except the following case the eggs failed to hatch.

A female of *polytes* form was confined with a male of *cyrus* form, both being from the above F_1 brood, on 26th August 1917 with a branch of *Murraya kœnigii*. Pairing was not observed in this case but on the morning of 28th August nine eggs were laid, and by the morning of 30th August nineteen eggs in all had been laid. The male died on 29th August and the female on the next day. The eggs began to hatch on the morning of 31st August, and of the larvæ four pupated on 11th, four on 12th, and four on 14th September. Of the 12 pupæ, eleven were green and one greenish mixed with straw-brown. The resultant butterflies emerged as follows :—

Date	Male normal (*polytes*)	Male (*cyrus*)	Female (*cyrus*)	Female (*polytes*)	Total
20th September . . .	3	...	...	...	3
21st September . . .	2	...	...	...	2
22nd September . . .	1	...	...	2	3
25th September . . .	...	...	...	2	2
Total .	6	...	...	4	10

T. Bainbrigge Fletcher.

177. Parata alexis as a pest.

Pongamia glabra is a common South Indian tree, being met with in numbers, especially in the upland tracts of the Mysore plateau. Though it is not a tree of great economic importance there are some ways in which the tree is made use of; oil is extracted out of the seeds and the foliage is used largely as green manure for wet lands. This tree has not been noted to suffer from the attacks of any insect pest seriously. But recently (in November 1914) at the Coimbatore Agricultural College Farm some young trees were found very badly attacked by the larvæ of the butterfly *Parata alexis,* Fabr. Though there are previous records of this butterfly larva feeding on this plant—especially by writers like Davidson Bell and Aitken in the *Bombay Journal*—I do not think that such serious attacks are common. Almost every leaf on the trees was folded up and contained a larva, and badly attacked trees were actually stripped of foliage and skeletonized.

The larva, which is stout in build with a spherical head separated from the trunk by a distinct constriction, appears more like the caterpillar of a moth than that of a butterfly. Each larva folds the leaf, bringing the lateral halves of it together and constructing a sort of flattish tube. From inside this structure it feeds on the leaf tissue. A full-grown caterpillar measures 35 mm. There is a good deal of variation in colour. The pupa is also found inside the tube; even this resembles a moth pupa. It is naked and smeared over with a scanty white powdery bloom. The body is fixed by the tail-end; but in addition to this there is a slender silk loop enclosing the middle portion of the trunk. The pupation period lasts from 9 to 10 days.

T. V. Ramakrishna Ayyar.

178. Synonymy of Polyocha saccharella and Anerastia ablutella.

Polyocha saccharella, Ddgn. (*B. J.,* XVI, 405, 1905), whose larva bores in the roots and shoots of sugarcane, has already been shown to be identical with *Polyocha depressella,* Swinh., of the *Fauna of India, Moths,* Vol. IV, p. 63, which has been removed from the genus *Polyocha* and is referred to as *Papua depressella* in the *Proceedings of the Second Entomological Meeting* (1917), pp. 141, 145 and 182. In his recent "Classification of the Pyralidæ, subfamily Hypsotropinæ" (*Proc. Zool. Soc.,* 1918, 55-131) Sir George Hampson sinks *Papua,* Rag., as a synonym of *Emmalocera,* Rag. [Nouv. Gen. p. 38 (1888); type *leucocincta*], so that this insect now stands on our lists as *Emmalocera* (*Papua*) *depressella,* Swinh. (*saccharella,* Ddgn.).

In this paper also the species hitherto known as *Anerastia ablutella*, Zell., is placed in the new genus *Raphimetopus*, Hmpsn. (*P.Z.S.*, 1918, 78; type *spinifrontella*), and *Anerastia bimaculella*, Rag., of the *Fauna* volume, is sunk as a synonym of *ablutella*. The distribution of *R. ablutella* is very wide, being given as the Mediterranean region, throughout Africa, Persia, Japan, Kashmir, Punjab and Madras.

T. Bainbrigge Fletcher.

179. Early stages of Pilocrocis barcalis.

A larva of *Pilocrocis barcalis* was found on 20th November 1914 hidden inside two superimposed leaves of *Cassia fistula* which had been fastened together with silk. The epidermis and mesophyll substance of the leaves had been mostly eaten, the eaten portions turning brown. The larva formed a cocoon on 21st November and the moth emerged on 18th December.

Pusa Insectary (Cage-slip 1143).

180. Early stages of Crocidophora ptyophora.

Larvæ of *Crocidophora ptyophora*, Hmpsn., were found at Pusa in January 1916 inside rolled green leaves of a newly-planted bamboo clump. In some cases several leaves had been rolled up and tied together by white, silken threads applied here and there, the whole bundle of rolled leaves making a cylindrical case of which the innermost leaf or leaves had been partially eaten by the contained larva. Pupation takes place, inside a longitudinally rolled bamboo leaf, in a silken cocoon covered with a thick layer of yellowish dry chewed-up leaf-fibre. From larvæ obtained between 3rd and 26th January moths emerged from 21st March to 15th May. The larvæ seem to rest inside the cocoons, before pupation, for a period which may extend to over two months.

Pusa Insectary (Cage-slip 1347).

181. Early stages of Monoschalis virescens.

The brightly coloured larvæ of *Monoschalis virescens* were collected by Sub-Assistant D. Ponniah from the foot of the Marudamalai Hills seven miles west of the Farm, Coimbatore. They feed on the leaves and burrow into the fleshy stems of *Vitis quadrangularis*. They were about 13 mm. long, stout, rather flattened and somewhat hairy. The caterpillar is dull brick-red with paired black and white patches

EXPLANATION OF FIGS. 46 AND 47.

Fig. 46. ***Pilocrocis barcalis.***

a, Leaf of *Cassia fistula* rolled and eaten by larva.
b, Larva, natural size and magnified (× 3).
c, Pupa, „ „ „ „
d, Imago, „ „ „ „

Fig. 47. ***Crocidophora ptyophora.***

a, Bamboo leaf rolled by larva.
b, Larva, natural size and magnified (× 4).
c, Cocoon, „ „ „ (× 2).
d. Imago, „ „ „ (× 4).

Fig. 46. *Pilocrocis barcalis.*

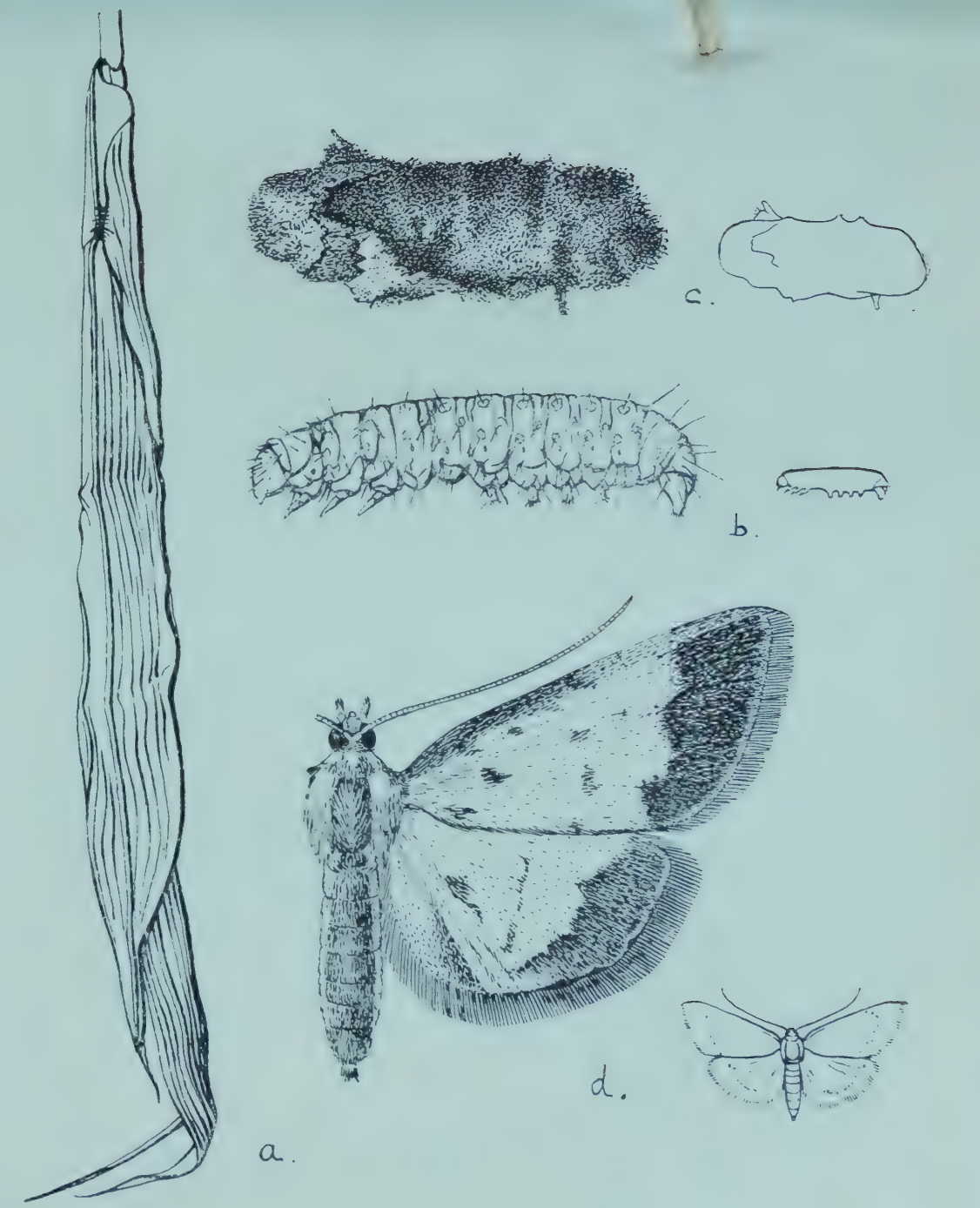


Fig. 47. *Crocidophora ptyophora.*

dorsally. The head is dark brown normally hidden under the hood-like prothoracic segment. The prothoracic shield is shiny brown with a faint white mid-dorsal line. The mesothorax is reddish and somewhat bulged. The metathorax is also reddish with a pair of small dark patches on dorsum. The number of legs and prolegs is normal. All the segments of the abdomen, except the second, fourth and fifth (which carry a pair of large black patches instead), bear dorsally a pair each of prominent bright whitish patches. Laterally there are two series of fleshy prominences, bearing greyish hairs one (small) above and the other (larger) below the line of spiracles.

When full fed they constructed their cocoons between folds of the leaves. The cocoon is held in position by a loose mesh-work of silk intermixed with a white meal-like material. It is thin, brownish in colour but very tough and fits well into the hollow of the leaf fold. The pupa is soft and pale. The abdominal segments are pale pinkish, while the head, thorax and wing rudiments are bright yellow. Hairs are absent.

They emerge in about a week into pale pretty little moths with a Syntomid-like appearance. The body and the wings are blue black with a faint metallic lustre. The abdomen is crossed by a dull red band about the middle. The antennæ are pectinate.

Y. Ramachandra Rao.

182. Larva of Thyrassia subcordata.

Larvæ of *Thyrassia subcordata*, Wlk., were found at Pusa on 7th August 1915 on *Vitis trifolia*, eating the leaves, buds, flowers and fruit, and the following description was made :—

About 12 mm. long by 3 mm. broad, slightly flattened. Head shining black, much smaller than prothorax into which it can be retracted. Prothoracic shield large, shining black, divided medially ; anterior edge of prothorax white. All segments distinctly defined, 13 divided into two distinct subsegments. Colour yellow, paler ventrally, but the ground-colour is concealed dorsally by the development of the setigerous tubercles which are blackish-brown and bear tufts of long hairs arranged in the form of rosettes. The position of these tubercles is as follows : – subdorsal (considerably extended laterad) on 3 to 12 and both subsegments of 13 ; supraspiracular on 3 to 12 ; spiracular on 3 and 4 ; subspiracular on 5 to 12 ; just above base of legs on 3 to 6 and 11. The prothorax carries a spot

just above the base of the leg and the four abdominal prolegs have also a basal spot. The mesothoracic warts are small whilst those on the metathorax are conjoined. The subdorsal and supraspiracular warts are conjoined on the abdominal segments, as are also those on the posterior anal subsegment. The subdorsal warts on 5, 7, 10 and 11 are white, thinly margined with black; these white spots are very prominent on the back of the larva. All prolegs present and equally developed.

The larvæ commenced to pupate on 15th August, forming a well-woven and matted cocoon of brown silk amongst leaves or inside a folded leaf. Pupa normal, compressed dorso-ventrally; it wriggles out to some extent through one end of the cocoon prior to emergence of the adult. The first moths appeared on 21st August.

Thyrassia subcordata is described and figured in the "Fauna" volume (Moths, I, p. 238, f. 154), where it is recorded from the Plains of N. India, S. India and Ceylon, but apparently the larva has not been described or figured previously.

In Java the larva of *Thyrassia procumbens*, Snell., is known and also feeds on *Vitis trifolia*. It is described and figured by Piepers and Snellen [*Tijds. voor Entom.*, XLV, p. 228, t. 13, f. 12 (1902)] and appears very similar to that of *T. subcordata*.

183. Pterophoridae from Coorg.

Amongst a general collection of insects made in Coorg whilst on tour in October-November 1915 were specimens of the following *Pterophoridæ*:—

(1) *Buckleria xerodes*, Meyr.—Pollibetta; one specimen. The larva feeds on *Gynandropsis* in Ceylon.

(2) *Buckleria wahlbergi*, Z.—Mercara, Pollibetta; common. The larva must feed on some common plant, but is not known as yet.

(3) *Sphenarches caffer*, Z.—Pollibetta; common.

(4) *Oxyptilus epidectes*, Meyr.—Pollibetta; common. The larva feeds on *Biophytum*, which was growing commonly in localities where the moths were found.

(5) *Deuterocopus ritsemæ*, Wlsm.—Pollibetta; one specimen. This species is known from New Guinea to Assam and Ceylon but has not previously been recorded from Southern India.

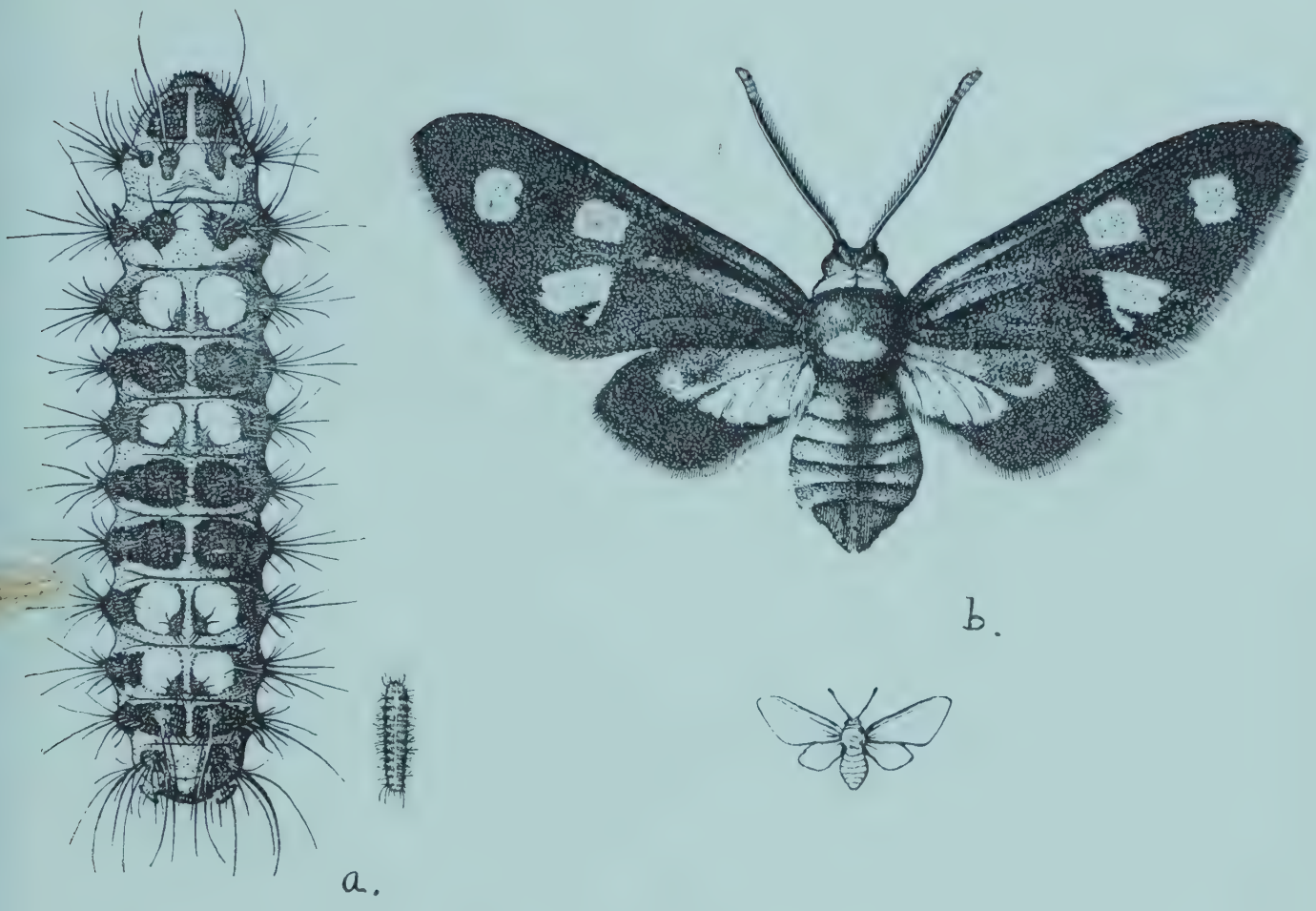


Fig. 48. *Thyrassia subcordata*
a, Larva, natural size, and magnified (×7).
b, Imago, „ „ „ (×5).

(6) *Deuterocopus planeta*, Meyr.—Pollibetta; three specimens. Originally described from Coorg and Assam.

(7) *Platyptilia brachymorpha*, Meyr.—Pollibetta; several. Widely distributed throughout India and Ceylon.

(8) *Platyptilia pusillidactyla*, Wlk.—Common everywhere in Coorg, the larva feeding in flowers of *Lantana*, whose output of seed is thereby reduced to a considerable extent.

(9) *Exelastis liophanes*, Meyr.—Virajpet; one. Probably common. The larva feeds on *Oxalis*.

(10) *Alucita melanopoda*, Fletcher.—Mercara; one. Originally described from Ceylon and the Khasi Hills. Not previously recorded from Southern India.

(11) *Steganodactyla concursa*, Wlsm.—Pollibetta; one. Previously only known from Ceylon, but I have found it at Belgaum also. The larva feeds between the unexpanded young leaves of *Argyreia*.

184. Pterophorus monodactylus in India.

Three specimens, collected at Parachinar, Kurram Valley, North-West Frontier Province, in September 1917, by Ahmad Mujtaba, seem referable to *Pterophorus monodactylus*, Linn. We also have a single specimen from Mansehra, Hazara District, North-West Frontier Province (A. Mujtaba coll.; September 1917), which is not in good enough condition for exact determination, but which is probably the same species. *P. monodactylus* is widely distributed throughout the Holarctic Region but has not been recorded from within Indian limits hitherto.

185. Synonymy of Eucosma critica.

In Note No. 76 I published a record of a new pest of Arhar under the name of *Laspeyresia trichocrossa*, Meyr. MS. On examination of further material Mr. Meyrick concluded that this was identical with the species described by him from North Coorg under the name *Eucosma ludicra* and, in reply to a note that this was the species hitherto standing in the Pusa Collection under the name of *Eucelis critica*, he writes (*in litt.*, 27th October 1916) :—"Your reference to *critica*, Meyr., has caused me to examine my (poor) specimens of this, and I find you are quite correct in your identification of it; I therefore (I regret to say) provided it with three names, and *trichocrossa* must drop. The species is variable and troublesome in markings; but in the male sex the black hairs of hindwings seem to be a quite peculiar character, and ought

to have ensured recognition. The reference to *Eucelis* was one cause of overlooking it, as that genus has been sunk; if however it were maintained as distinct from *Eucosma* (the distinguishing character is the nearly parallel vein 5 of hindwings), *critica* would be correctly referable to it."

The synonymy will therefore be :—

Eucosma critica, Meyr.

Eucelis critica, Meyr., B. J. XVI 587 (1905)[1]; Lefroy, Ind. Ins. Pests, p. 143[2], Ind. Ins. Life, p. 530 t. 55 (1909)[3]; Fletcher, S. Ind. Ins. p. 450 t. 39 (1914)[4].

Eucosma ludicra, Meyr., B. J. XXI 867 (1912)[5].

Eucosma trichocrossa, Meyr., Exot. Micr. I. 563-564 (1916)[6].

Laspeyresia trichocrossa, Fletcher, Pusa Bull. 59, p. 28, Note 76 (1916)[7].

Localities:—Surat[1] —North Coorg[5]—Pusa[6]—South India (Plains)[7].

186. Two new Indian Species of Cosmopteryx.

The two following species have been recently bred from the larvæ in the offices of the Indian Imperial Entomologist, and are of interest; their full lifehistory will be published by Mr. Fletcher. The perfect insects need very accurate discrimination.

Cosmopteryx phæogastra, Meyrick.

♂ ♀ 7-8 mm. Head dark bronzy-grey, with fine white lines on crown and above eyes, face bronzy-whitish. Palpi white line with black. Antennæ black lined with white, four apical joints white, then three black, one white, one black, one white, one black, three white with dark bases. Thorax bronzy-blackish with white central line posteriorly. Abdomen uniform dark grey. Forewings narrow-lanceolate, apex produced, acute; blackish; a fine white subcostal line from base to ¼, diverging from costa posteriorly, and short median and subdorsal lines beneath posterior portion of this, widely remote from base and band, subdorsal rather posterior; costal edge shortly white before band; a broad pale ochreous-yellow post-median transverse band, edged by slender irregular golden-metallic fasciæ, first nearly direct or slightly outwards-oblique, followed above middle by a black dot,

second slightly inwards-oblique from costa, preceded by small indistinct blackish dot beneath costa, interrupted in middle by a short pale yellow projection, whence a white line runs along termen to apex: cilia grey, with a whitish spot beyond band, and a fine white bar at apex. Hindwings dark grey; cilia grey.

Bihar, Pusa, bred in July from larvæ mining blotches in leaves of bean (*Fletcher*). Extremely like *liggrodes*, but distinguished by uniform dark grey (not yellowish-mixed) abdomen, and pale ochreous-yellow (not orange-yellow) band of forewings.

Cosmopteryx bambusæ, Meyrick.

♂ ♀ 8-10 mm. Head and thorax dark fuscous with three very fine white lines, face pale silvery-bronze. Palpi white lined with black. Antennæ black lined with white, three or four apical joints white, then four black, one white, one black, two white, two black, three white. Abdomen grey, in ♂ bronzy-shining. Forewings very narrow-lanceolate, apex long-caudate; dark fuscous, apical area beyond band grey; a very fine white subcostal line from base to beyond $\frac{1}{4}$, diverging from costa posteriorly, and extremely fine median and subdorsal moderate lines, median not nearly reaching base or band, subdorsal posterior, approaching band; costal edge shortly white before band; a broad pale ochreous-yellow postmedian transverse band, margined by narrow pale golden-metallic fasciæ, first slightly outwards-oblique, followed by a black dot above middle and enlarged on lower half into an unusually raised round spot projecting posteriorly, second somewhat inwards-oblique from costa, interrupted above middle by a pale yellow projection, whence a white line runs along termen to apex: cilia light grey, with whitish spot on costa beyond band. Hindwings grey; cilia light grey.

Bihar, Pusa, bred in October from larvæ mining blotches in leaves of bamboo (*Fletcher*). Nearest *spiculata*, but the median line of basal area does not nearly reach base as in that species; the apical area much lighter than ground-colour is a noticeable feature, but is apparent though less marked in *spiculata* also; in the allied *manipularis* the apical area is concolorous with the basal. A pupa-case sent (very little discomposed by the emergence of imago through a small slit) shows only two abdominal segments free, the rest fixed, wing-cases reaching to end of penultimate segment.

[E. Meyrick in *Entom. Mo. Mag.*, LIII, pp. 257-258, Nov. 1917.]

187. Melasina taprobana in India.

Melasina taprobana was described, under the name *Alavona taprobana*, from Ceylon in Moore's *Lepidoptera of Ceylon*, Vol. III, p. 503, t. 208, ff. 7, 8 (1887). It has not hitherto been recorded from India but the Pusa collection contains a specimen, identified by Mr. Meyrick and collected at Tanjore in March 1913.

188. Two Pentatomids swarming on Pongamia glabra.

In January last I came across numbers of the tree *Pongamia glabra*, pretty old trees, growing as avenue trees on both sides of a trunk road in South Malabar literally covered—stem, trunks and shoots—with thousands of the Pentatomid bug *Cyclopelta siccifolia*, Westw., which has till now been noted on *Erythrina* in pepper and betel-vine gardens on the West Coast.

Very recently, a few days ago I found the same phenomenon, but in this case though the tree was the same the bug happened to be the common *lablab* Pentatomid *Coptosoma cribraria*, Fb. Every shoot and tender trunk was covered up by myriads of this insect. I have also found this insect exhibiting this habit on *Sesbania* (*Agathi*) plants.

T. V. Ramakrishna Ayyar.

189. Occurrence of Ochrophara montana in swarms.

In July 1917 Mr. R. D. Anstead sent in some specimens of *Ochrophara montana*, Dist., which he had received from Mr. C. H. Browne, Sallebile Estate, Kadur District, Mysore State, who wrote as follows:—"I am situated on the western, or monsoon, side of a big hill. Last Sunday (1st July) I climbed it, and on crossing the top I found the whole hill one mass of these insects, every tuft of grass held thousands, if not millions of them; as we walked along they rose in clouds. Eventually I got into the top of my Yelliemudloo coffee and from a short distance it appeared to have suffered from a cyclone, the shade trees (*Grevillea robusta*) had their branches bent or broken and lying about all over the place. On getting near I found it was due to the leaves and branches being laden with these insects. When I tell you that branches thicker than my arm, which would have supported a man without breaking, were snapped off, you will form some idea of the number there were hanging on to it. The coffee was also covered but to a less degree. It was a most remarkable sight and I regret I had not a camera with me. You will notice that there were none on the

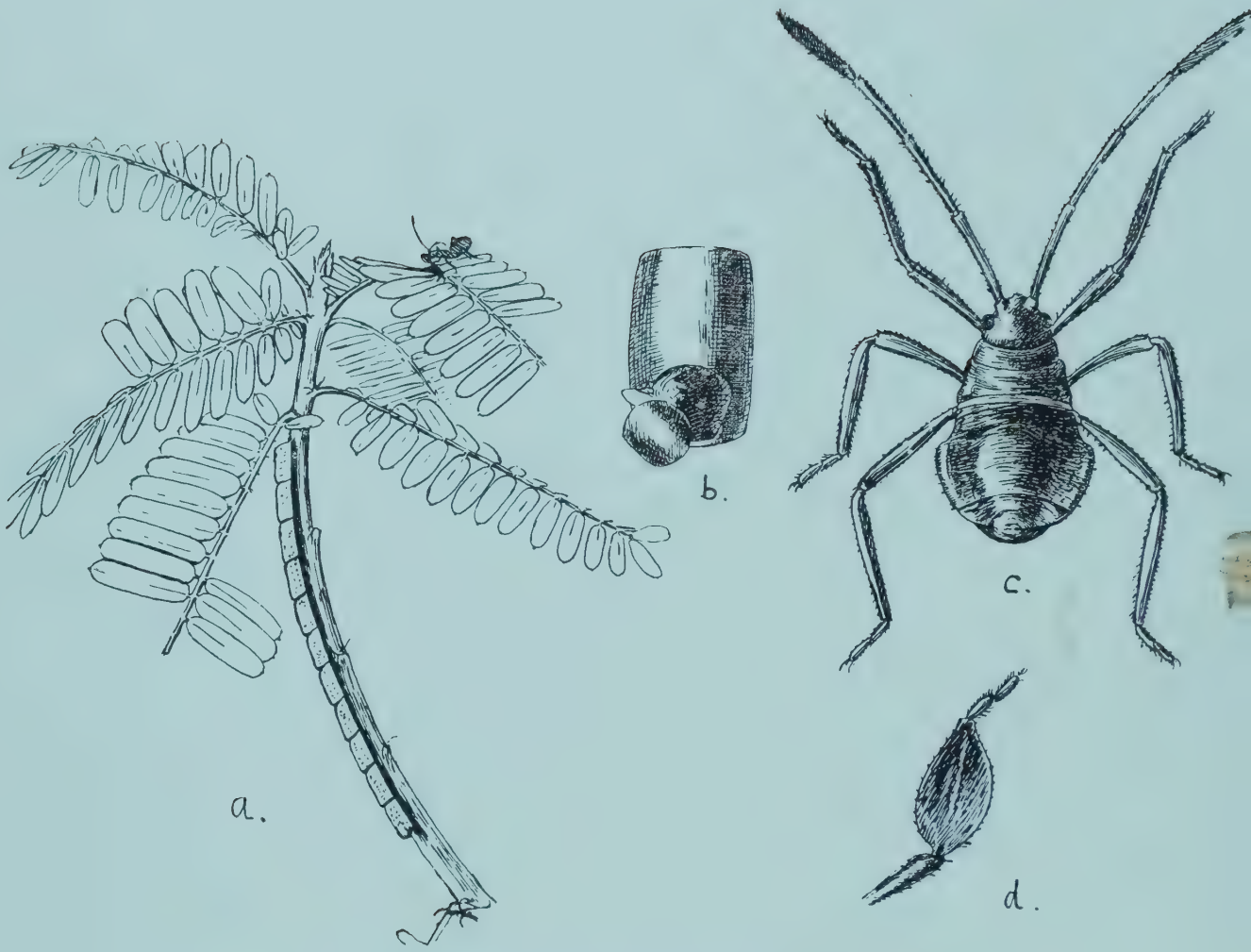


Fig. 49. *Axoplocnemis phasiana.*

a, *Sesbania* twig, showing eggs deposited on stem and a young nymph on a leaf, sli
enlarged ($\times 1\frac{1}{3}$).

b, Egg-shell after emergence of young nymph ($\times 8$).

c, Nymph in second instar, magnified.

d, Fore-tibia of nymph in second instar, more highly magnified.

weather side of the hill and beyond damage done by their weight they seem to have no evil designs on vegetation."

This Pentatomid bug seems to occur fairly often in large swarms. We once had it sent in under rather similar circumstances by Mr. Graham, from Hallery Estate, near Mercara, Coorg, and when I was at Pollibetta in May 1914, I saw a similar occurrence on some trees near there.

Some light as to the cause of the sporadic occurrence of *O. montana* in such large numbers is given by the following remark by Mr. W. L. Distant (*Fauna of India, Rhynchota,* Vol. I, p. 147) :—"Mr. L. de Niceville forwarded to me specimens for identification and wrote :— "In Chanda (Central Provinces) reported to be doing immense damage over 1,200 square miles of country to the bamboo-seed crop. As is generally known, the bamboo but seldom flowers, and when it does—often after a famine—the seed is a valuable food for the starving people." Mr. E. P. Stebbing, Forest Entomologist to the Government of India, has given the same report and forwarded specimens. He identifies the bamboo as *Dendrocalamus strictus.*" Mr. Browne says nothing in his letter (*supra*) about the flowering of bamboos in the Kadur District, but they had certainly flowered in Coorg just previous to my visit in 1914. So it appears probable that the occasional seeding of bamboos provides favourable conditions for the breeding of these bugs which, on the exhaustion of the bamboo seeds, move upwards in search of more food and thus congregate into large swarms on hill-tops and tall trees.

As Mr. Distant remarks (*loc. cit.*), this species is structurally remarkable in having the pronotal angles either obtusely rounded or provided with a short acute forwardly-directed spine, which in some specimens is on one angle only. This character is well represented in the series in the Pusa Collection from Mysore and Coorg.

Ochrophara montana is recorded by Distant from the Naga Hills, Chanda, and Burma from Bhamo to Tavoy. The Pusa Collection contains examples from Mysore, Coorg and Assam.

T. Bainbrigge Fletcher.

190. Early stages of Anoplocnemis phasiana.

Anoplocnemis phasiana is widely distributed in India and occurs on many plants, among which have been noted brinjal, indigo, *Cajanus indicus, Phaseolus mungo, Andropogon Sorghum, Erythrina indica* and *E. lithosperma.* It has been noted in small numbers on indigo at

Cawnpore and is often a serious pest of *Erythrina* in Southern India and Ceylon.

An adult pair, found at Pusa on indigo on 13th June 1917, was confined with a plant of *Sesbania ægyptiaca*, on which the female was observed to feed and on which she deposited eggs, thirty-seven eggs being deposited in all, and these were laid in long rows, all the eggs in the row lying lengthwise and touching one another at their ends. The egg is about 2·5 mm. long by 1·5 mm. broad, a transverse section being ∩-shaped, the flat side in contact with object to which the egg is attached, the ends truncated and flat; surface smooth, brown, coated with white powder. The young nymph hatches out by pushing open a circular, lid-like portion of the shell on the upper surface near one end of the egg. Eggs laid on 21st June hatched on 27th June and the first moult occurred on 30th June.

The newly-hatched nymphs are black and cluster together, resembling *Camponotus* ants. After the first moult the fore-tibia becomes much enlarged and flattened and the young bug then looks much like a young Mantid.

Pusa Insectary (Cage-slip 1596).

191. Notes on the Life-history of Megacoelum stramineum.

Megacœlum stramineum, Walk. (*Capsus*) Cat. Het. VI., p. 120 (1873). Distant; Fauna of British India, Vol. II, Rhynchota Heteroptera, p.428 (Figs. 50 and 51).

Megacœlum stramineum, Walk., is described in the *Fauna of British India* as follows :—

Pale ochraceous, corium with a slight virescent tinge; eyes and apex of scutellum piceous; apical area of posterior femora testaceous; membrane pale hyaline; head with a distinct central longitudinal sulcation; antennæ with the first and second joints luteous, remainder fuscous; head pronotum and scutellum very finely ochraceously pilose; tibi longly setose.

Length 7 to 8 millim.

The localities are given as North Bengal, Kangra valley and Ceylon (Pundaluoya). It is common in Madras Presidency and presumably all over India. It occurs as a pest of *Andropogon Sorghum* (Cholam) in the Madras Presidency. It appears to affect chiefly the ripening grain in which its eggs are laid and on which it feeds. By these

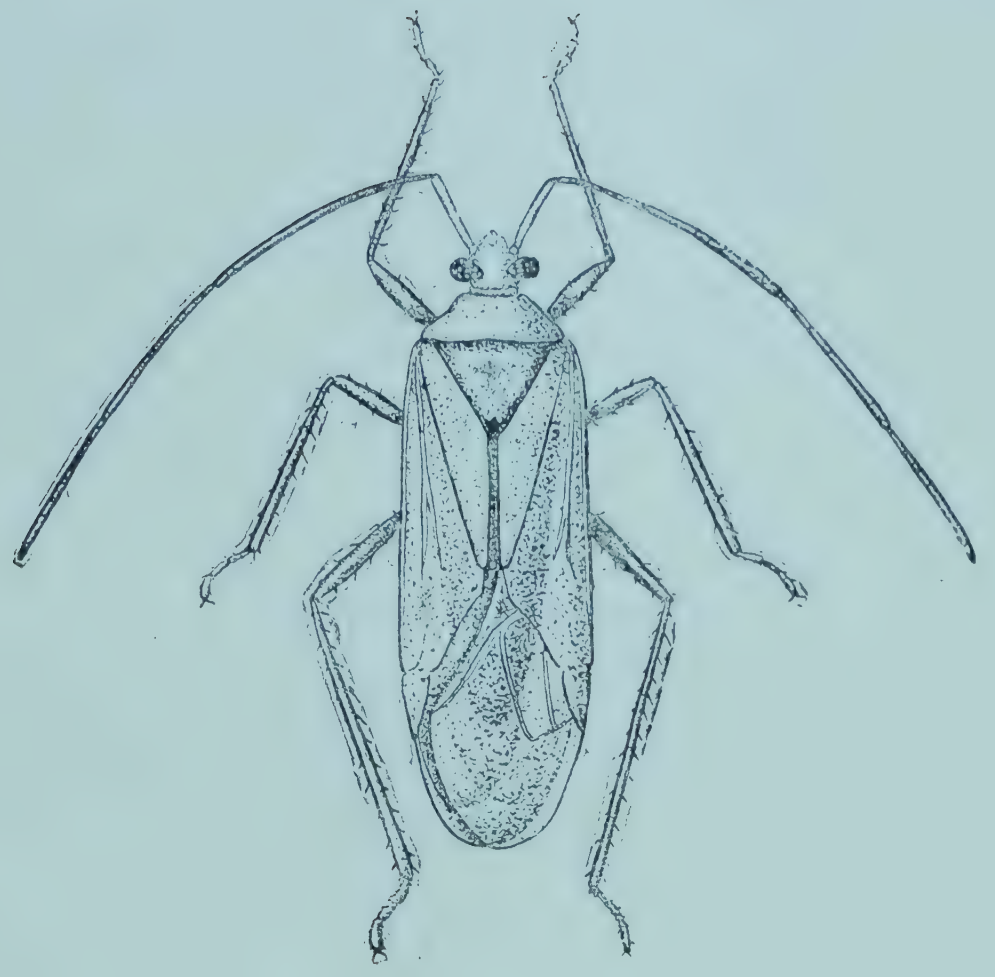


Fig. 50. *Megacœlum stramineum*, a lult ma'e.

Fig. 51. *Megacœlum stramineum*, adult female.

Fig. 52. Eggs on grain of *Sorghum* (tops alone seen).

Fig. 53. One complete egg (grain cut open to show the whole egg).

Fig. 54. Egg magnified (× 20).

Fig. 55. First Instar.
Megacœlum stramineum. Different stages in the life-history.

habits it supplements the destructive work of *Calocoris angustatus* with which it is nearly always found but which damages the immature and unfertilized florets.

Once identified the eggs are easily found and very characteristic. They are laid in the grain when in the "milk" stage, sometimes as many as fifteen being laid on one grain, in captivity, but in the field not more than one have been found in one grain (Fig. 53).

They are pushed into the grain by means of the short powerful ovipositor and only the top projects from the surface of the grain. Through this end the nymphs emerge, the top of the egg opening like a trap door.

The nymphs attain maturity in ten to eleven days, moulting five times in the process.

The adults are prolific egg-layers, as many as 199 eggs having been recorded as laid by one female.

The eggs are laid in the ripening grains. They are elongated, slightly curved, and provided with a conspicuous white ridge or collar, part of of which is prolonged to form an erect "Tag" or "Handle."

Nearly the whole of the egg is pushed into the grain, only a small portion and the collar projecting above the surface. In cross section the eggs are elliptical. The colour is purely white. Hatching usually takes place in six or seven days. Very little trouble was experienced in hatching eggs in the Insectary. It was not necessary to take any special precautions to ensure the correct amount of moisture or heat.

The number of eggs laid by a single female appears to be between 150 and 200. Egg records taken in four cases were as below :

1st case	.	.	.	199
2nd case	.	.	.	156
3rd case	.	.	.	156
4th case	.	.	.	2 females let in the same cage laid between them 277 eggs between 7th and 25th of July. It should however be noted here that one of the insects died on 16th, and after that 95 eggs were laid by the survivor between 17th and 25th July.

The eggs hatch in 5 to 6 days.

The nymphs of the first instar have the body a uniformly green colour. The antennæ are banded with seven bands of reddish purple. Round the eyes are reddish spots which extend backwards along the sides of the thorax (Fig. 55).

There are three reddish brown bands on the femora and slight banding is visible on the tibiæ. The most distal tarsal joint is black and

the first dark. The proboscis reaches back to the last pair of coxæ. The length of the nymphs in this instar is between 1·5 and 1·75 mm. The duration of this stage is between 2 and 2½ days after which period the first moult takes place.

After this event very little change is to be noted save that the banding of the legs is fainter than in the first instar.

Two days later the second moult occurs (Fig. 56). The leg banding can still be seen. The first tarsal joint is pale brown in colour as is the distal up of the tibiæ in the case of forelegs and black in the case of the last pair. The antennæ are banded as before. The wing pads are slightly indicated.

The third moult is passed through two days later. The body is covered with short black setæ. The first joint of the antennæ is grey brown and covered with black hair. The other joints of the antennæ are still banded and have the ultimate and penultimate joints dark at their distal end. The legs are greyish brown, setose and the last tarsal joint is black. The hindmost femora are faintly banded with red. The wing pads are more distinct than in the last instar and reach to the second abdominal segment. This stage lasts for two days.

The fourth moult then takes place, after which it is seen that all traces of banding have passed from the legs. The penultimate joint of the antennæ is dark at the tip and the last joint almost entirely dark. The wing pads now reach to the fourth abdominal segment. The antennæ are pale brown and the last tarsal joint dark. The stripes about the eyes are represented by two lines of reddish dots. The legs are pale green in colour, rather deeper on the femora. Two black dots are to be seen at the posterior edge of the metanotum.

At the fifth moult the adult form is attained.

Eggs laid	Time of hatching of eggs	First moult	Second moult	Third moult
1	2	3	4	5
5th to 6th March	12th to 13th Mar.	15th Mar. 4 P. M.	16th to 17th Mar.	19th Mar.
Ditto	Ditto	15th Mar. 9 A. M.	Ditto	18th Mar.
6th to 7th March	13th to 14th Mar.	16th to 17th Mar.	17th to 18th Mar.	19th to 20th Mar.
.....	15th to 16th Mar.	17th to 18th Mar.	19th to 20th Mar.	21st to 22nd Mar.
.....	16th to 17th Mar.	19th Mar.	20th to 21st Mar.	22nd to 23rd Mar.

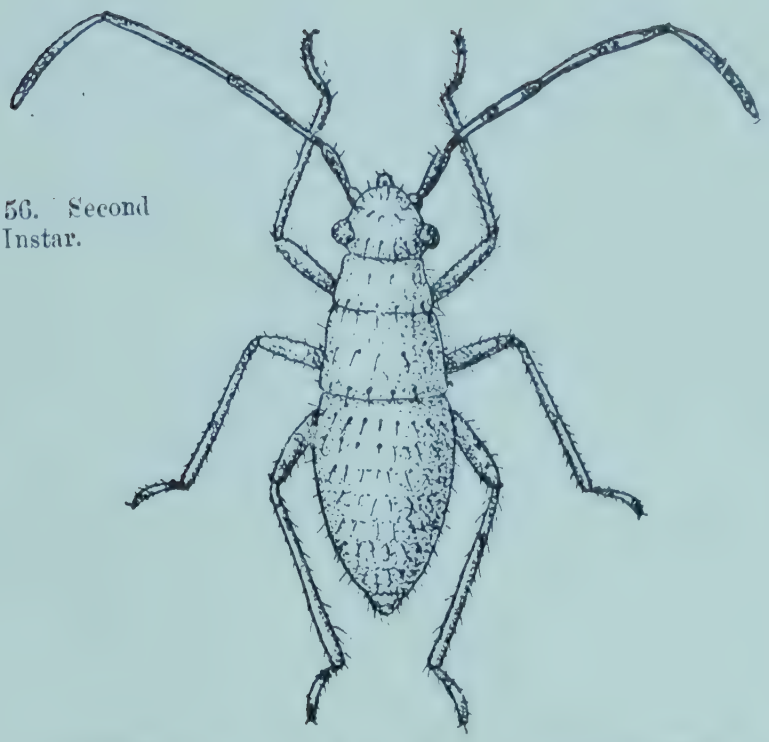


Fig. 56. Second Instar.

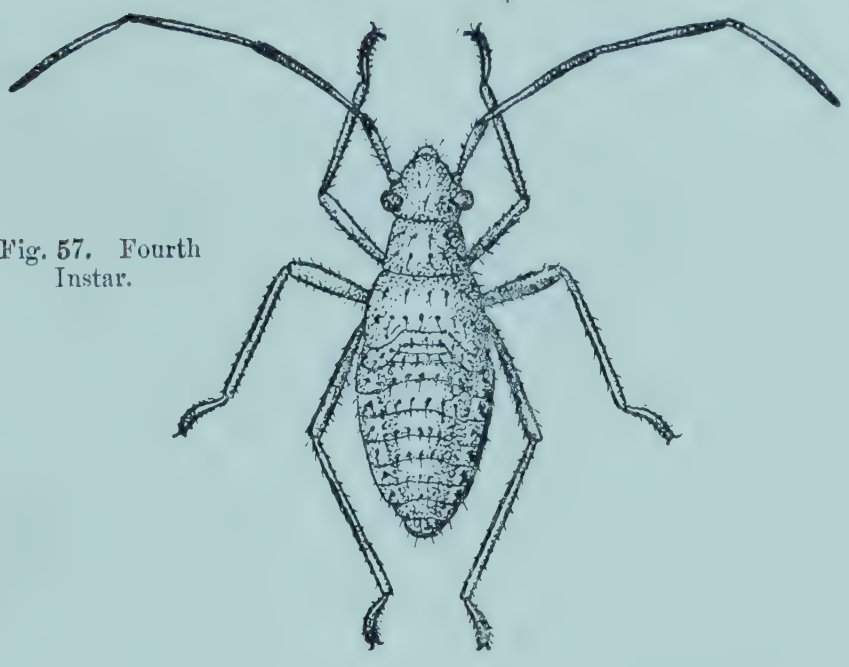


Fig. 57. Fourth Instar.

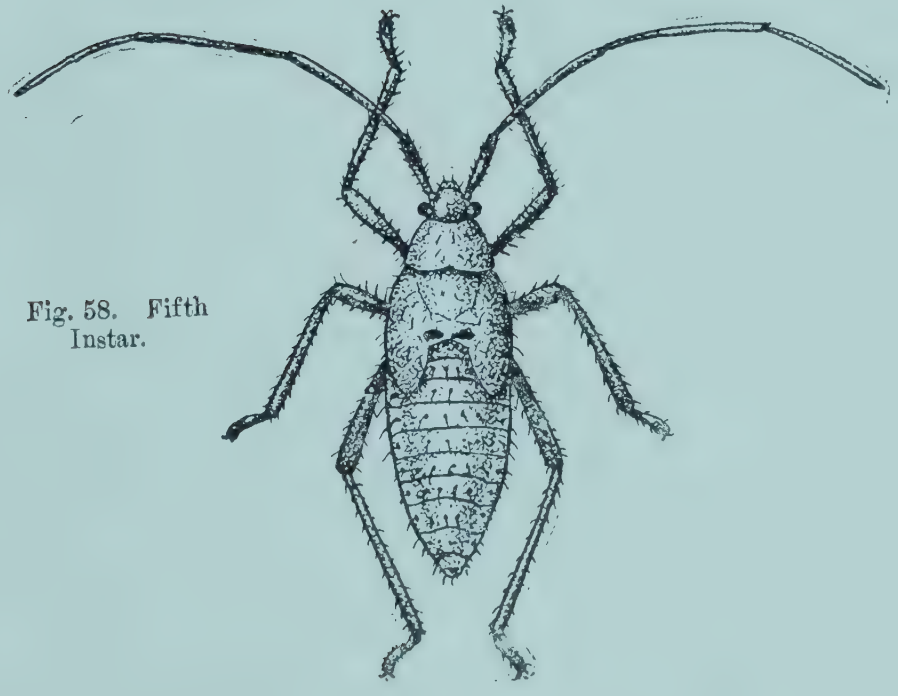


Fig. 58. Fifth Instar.

Larva stages of *Megacœlum stramineum.*

Eggs laid—contd.	Fourth moult	Fifth moult	Remarks
	6	7	8
5th to 6th March . .	21st Mar. .	24th Mar. .	♀
Ditto . .	19th to 20th Mar.	23rd Mar. .	♂
6th to 7th March . .	21st to 22nd Mar.	24th to 25th Mar.	♀
.....	24th Mar. .	26th to 27th Mar.	Died in act of fifth moult.
.....	23rd to 24th Mar.	25th to 26th Mar.	♂

The amount of damage done by *Megacœlum stramineum* is not so great as in the case of *Calocoris*. At the same time it must considerably hinder the proper ripening of the grain. No effective methods have yet been devised for destroying or checking it, and with the exception of an Acarid found in one case badly infesting an adult female, no natural enemies have been found.

Megacœlum is found chiefly as a pest of rain-fed *cholam* which is harvested in January-February. It does not appear in any numbers in the irrigated *cholam* grown under wells during the hot weather. It has been found hiding in the central leaf whorl in young *cholam* and *cumbu* and has also been observed on various other crops such as groundnut and gingelly.

E. Ballard.

192. A natural enemy of the mango hopper.

Very recently while in Bangalore I visited a few mango gardens in the city just to have an idea of the extent of mango hopper attack this year. While examining some badly infested trees I came across numbers of the nymphs and adults of a Reduviid bug, a species of *Isyndus* (probably *I. heros*, Fabr.) (See *F. B. I., Rhynchota*, II, p. 376) ; watching a few of these for some time I found the bug attacking the Jassid and acting as a predator. The nymphs are beautifully coloured in shades of scarlet blue black and white ; the regions occupied by the two rudimentary tegmina showing a conspicuous white multiplication mark. Though this bug does not play a very prominent part as an efficient natural check on such a serious pest as the mango hopper, it will be interesting to note which

are the natural enemies of the latter. I have not seen this insect either in Chittoor or Salem though hoppers abound in these two well-known mango tracts.

T. V. Ramakrishna Ayyar.

193. Aleyrodidae on Citrus plants.

Since listing the Indian species of Aleyrodidæ (Note 98), some new species, found on *Citrus* plants, have been added in a paper entitled " Aleyrodidæ or White Flies attacking the Orange, with descriptions of three new species of economic importance ", by A. L. Quaintance and A. C. Baker (*Journ. Agricl. Res.*, VI, pp. 458-472, figs. and tabs.).

Aleurocanthus citriperdus, Q. & B., was found at Peradeniya on an unknown tree and on *Citrus* at Lahore and in Java. It is probably widely distributed in India " and is regarded as of considerable economic importance."

Aleurocanthus woglumi, Ashby, is common and widely distributed on orange in India and Ceylon and has also been found in the Philippines and has been introduced into Jamaica, Cuba and the Bahamas.

Aleurocanthus spiniferus, Quaint., was found on *Citrus* in Java and Macao.

Aleurolobus marlatti, Quaint., has been found on *Citrus* at Lahore and in Japan, also on *Morus* at Lahore and on *Ficus* at Peradeniya, and in Java on an unknown tree.

Bemisia giffardi, Kot., was found on an unknown tree at Lahore. It is abundant on *Citrus* in Hawaii, where it has probably been introduced.

Dialeurodes citri, Ashm., is widely distributed in India, Ceylon, China, Japan, etc., and has been introduced into Florida, Illinois and California.

Dialeurodes citrifolii, Morgan, a noxious species in the Southern United States, has not yet been noted in India or Ceylon, but is considered to be almost surely oriental.

A later " Contribution to our knowledge of the White Flies of the Subfamily Aleyrodinæ (Aleyrodidæ)" has also been published in *Proc. U. S. Nat. Mus., Washington*, Vol. LI, pp. 335-445, 46 tabs., and may contain further information on Indian species but copies of this paper have not yet come to hand.

T. Bainbrigge Fletcher.

194. Notes on new and unrecorded species of Indian Coccidae.

At the fifth session of the Indian Science Congress held at Lahore I submitted a paper on "Some South Indian Coccidae of Economic Importance" wherein I listed some species which from their food habits appear to be of some importance from an economic point of view. My studies with this group of insects was continued during the past year, and of the 127 species which I have so far been able to verify definitely out of my collected material, 17 appear to be species quite new to science and the rest are those, which though not new to science, have not been recorded from India till I found them. In all 56 species are noted in this paper.

I have in this paper attempted to list these forms adding just what little notes I have on each. The paper is necessarily incomplete, as new and unrecorded forms are still being found. It is, however, submitted solely with the idea of getting into touch with other workers in the same field, if any, inviting their remarks and thus help to bring up our knowledge of these little known insects to a more or less complete and up-to-date condition. I am indebted to Professor Newstead, F. R. S., and Mr. E. E. Green, F.E.S., for kindly determining my material submitted to them. The descriptions of all the new species have not yet been published. Those of one or two which have recently appeared have been inserted in this paper.

1. Monophlebus tamarindus, Green.

Locality. Samolkotta, Godavari District. *Habitat.* On garden crotons (June). The adult ash-coloured females are strongly built and $\frac{1}{3}''$ in length ; they are found in numbers on the tender shoots.

2. Walkeriana pertinax, Newst.

Locality. Bangalore (June). *Habitat.* Wild plant. Only one adult female got. A number of larvæ were found under the scale. This species was first described by Professor Newstead in the *Proceedings of the Zoological Society,* 1900, from specimens collected in Africa.

3. Orthezia insignis, Dougl.

Locality. Bangalore (November). *Habitat.* On *Lantana.* These were found only on a few plants on which the insect was artificially reared ; the original specimens were accidentally found on a coffee plantation in the Nilgiris. This is the well-known *Lantana* bug of Ceylon and other countries.

4. Anomalococcus indicus, Green.

Locality. Coimbatore. *Habitat. Acacia arabica* (Babul tree), almost all through the year. Young trees when badly infested suffer a good deal. The common black ant (*Camponotus*) visits the scales in numbers. The adult insect is spherical and has a pale whitish colour; the young ones are flattish and of a pale yellowish colour. A Noctuid caterpillar (*Eublemma scitula*) is commonly found preying on the scale.

5. Eriococcus araucariæ, Mask.

Locality. Lal Bagh gardens, Bangalore, 3,000 feet. *Habitat.* On the shoots of a conifer; found as a white mass; badly infested shoots get a black sooty colour.

6. Eriococcus lagerstrœmiæ, Kuwana.

Locality. Courtallum, Tinnevelly District. *Habitat.* On a species of *Dalbergia.*

7. Corococcus bryoides, Mask.

Locality. Madras. *Habitat.* On *Hibiscus rosa-sinensis.*

8. Asterolecanium miliaris, var. *longum*, Green.

Locality. Coimbatore. *Habitat.* On the leaves of ordinary bamboo, almost all through the year; the scales are green and elongate. Does not produce any serious damage. First described by Green from Ceylon.

9. Pseudococcus corymbatus, Green MS.

Locality. Malabar, Coimbatore and Godavari districts. *Habitat.* On tender shoots of jak tree, on cotton and on *Citrus* plants. Colonies of this mealy bug cover the plant shoots in thick cottony masses. Numerous ants visit the colonies.

10. Pseudococcus crotonis, Green. (*nom nud.*)

Locality. Coimbatore and Vizagapatam districts.

Habitat. On shoots of *Adenophyllum*, on fruit stalks of pomegranate and on stem and crevices in stem of the banyan tree.

11. Phenacoccus mangiferæ, Green.

Locality. Coimbatore and Vizagapatam. *Habitat.* On mango leaves and shoots of *Echitis.*

12. Phenacoccus ballardi, Green MS.

Locality. Coimbatore and South Kanara. *Habitat.* I found this form on mango and on a wild plant. The following is the description of this new form by Professor Newstead :—

"*Female adult.* Dorsum, in dried example, covered with a felted mass of white secretion, completely obscuring the segmentation; margin with a conspicuous fringe of extremely long, white appendages, which are shortest in front; those arising from the cephallic margin about three times the length of the felted dorsal area. Length, inclusive of the fringe, 10 mm.

"Form after maceration in potash, slightly elongate ovate. Antennæ of nine segments, the articulation of the third and fourth less pronounced than the rest. Eyes small, but prominent. Legs slender, longer than the antennæ; tarsal digitules simple bristels; those of the claw very long and dilated; two strong apical spines on all the tarsi, margin with a complete series of inconspicuous spines tubercles, the spines short and truncate; between them and surrounding them a number of large circular pores; two or three long hairs accompany each of the abdominal groups of spines. Anal lobes similar to the marginal ones. Anal ring with six hairs. Integument with a few minute scattered spines and small circular pores, the latter most numerous on the terminal abdominal segments. Length of macerated specimens, 1·7-2·0 mm.

"*Female, second stage.* The marginal appendages similar in their arrangement to those in *Pseudococcus* (*Dactylopius*) *longispinus*, Targ., but they are much longer and arranged radically: posterior pair longest. Form, after maceration, elongate. Antennæ of six or seven segments. Marginal series of spinose tubercles not so clearly defined as in the adult. Integument with numerous minute spines; and there are two or three very long hairs arising from near the anal spinose lobes.

"Very like *P. iceryoides*, Green. (*Mem. Dept. Agr., India*, II, page 26), in having a conspicuous fringe of white filaments; but in Green's species the ♀ has a fringe of short, stout, conical spines which extend into broad clusters on the abdominal segments; whereas in *P. gracilis* the spines are truncate and their arrangement similar to those in *P. insolitus*, Green (*i.e.*), but in the latter spines tubercles are present also on the dorsum.

"South India, Coimbatore, on mango (10th Feb. 1914); South Canara District, on an unnamed plant (September, 1913). (T. V. Ramakrishna per E. Ballard.)"

13. Phenacoccus ornatus, Green MS.

Locality. Courtallum, Tinnevelly District. *Habitat.* On a wild creeper. A very beautiful delicate white insect found in numbers on the host plant.

14. Antonina maritima, Green.

Locality. Coimbatore. *Habitat.* Found attached to the underground roots of grass (*Cynodon* sp.).

15. Pulvinaria maxima, Green.

Locality. Coimbatore. *Habitat.* Very common on Nim (*Melia*) trees, doing often considerable damage to them. The leathery adults and the long white ovisacs are prominently seen in numbers on badly infested plants. Found recently on mulberry shrubs and cotton also. The species was first described by Green, from Javanese specimens found on *Erythrina,* in the *Entomologist's Monthly Magazine,* 1904. It promises to become a pretty bad pest.

16. Pulvinaria thespesiæ, Green.

Locality. Coringa, Godavari District, and Papanasam, Tanjore District. *Habitat.* On the Portia tree (*Thespesia populnea*). Very similar to *P. maxima,* Gr., in almost all characters. Green described the insect for the first time in Ceylon from specimens found on the same foodplant.

17. Inglisia chelonioides, Green.

Locality. Coimbatore. *Habitat.* On *Parkinsonia aculeata.* The insects are liable to be mistaken for the thorns of this plant unless carefully examined. The adults are very pretty looking insects with the glassy conical test. First noted in Ceylon from a single example on *Gelonium lanceolatum.* I have recently sent good material of this to Mr. Green, who described it first.

18. Lecanium hesperidum, L.

Locality. Madilagam, South Malabar, and Mandapetta, Godavari.
Habitat. On coconut leaf and *Citrus* shoots. This is a well known scale in the New World and affects a variety of plants. Is perhaps an introduced form.

19. Lecanium longulum, Douglas.

Locality. Mandapetta, Godavari District. *Habitat.* On stem of red gram plants. Green has noted this on *Acacia, Albizzia, Loranthus,* etc., in Ceylon.

20. Lecanium ramakrishnæ, Green MS.

Locality. Kothapetta, Godavari District. *Habitat.* On distal shoots of *Ficus bengalensis.* The scales have a bluish black colour.

21. Lecanium signiferum, Green.

Locality. Golgonda (Vizagapatam District). *Habitat.* On plantain leaf. Previous record from Ceylon.

22. Lecanium adersi, Newst.

Locality. Coimbatore. *Habitat.* On mango leaves. Professor Newstead has very recently described this for the first time from African specimens on mango. The following is the description :—

"*Female adult.* Very flat, irregularly ovate, and narrowed in front. Colour varying from chocolate-brown to brownish buff. Antennæ of six or seven segments; in the latter the fourth is much the longest; in some examples the articulation of the third with the fourth is very faintly indicated or entirely absent. Legs long and slender, especially the middle and hind pairs. Stigmatic clefts invaginated; stigmatic spines stout, bluntly pointed and of varying lengths; there are from twenty to twenty-two of these organs. Marginal spines falciform and finely serrated on one side. Anal lobes with the base exceedingly short, and the outer edge very long and strongly curved or arched. Anal cleft about one-fifth the length of the body. Derm cells minute and very widely separated; there are similar organs grouped together just in front of the anal orifice.

"Length. 4·75—5·0 mm.

"Closely allied to *Lecanium bicruciatum,* Green, from which it differs chiefly in the multiplication of the stigmatic spines."

23. Lecanium tessellatum, Sign.

Locality. Coimbatore (April). *Habitat.* On *Calophyllum* leaves. The scales are reddish brown, flattish and oval in shape.

24. Lecanium acutissimum, Green.

Locality. Coimbatore. *Habitat.* On coconut leaf and very rarely on mango leaf also.

25. Lecanium discrepans, Green.

Locality. Palacole, Godavari District, January. *Habitat.* On mango leaf—covered over by webs of a species of ant.

26. Lecanium ophiorrhizæ, Green.

Locality. Patti Konda, Kurnool District.
Habitat. On *Diospyros chloroxylon.*

27. Chionaspis varicosa, Green.

Locality. Sidapur, Coorg (May). *Habitat.* On pepper stem. The name of this species is changed by Cooley to *Phenacaspis varicosa.*

28. Chionaspis nilgirica, Green MS.

Locality. Ootacamund, Nilgiris, 7,500 feet. *Habitat.* On *Loranthus.*

29. Chionaspis spiculata, Green MS.

Locality. Chanthanathode, Western Ghats, 1,500 feet.
Habitat. On bamboo leaves.

30. Chionaspis acuminata, Green.

Locality. Coimbatore, Tinnevelly and Western Ghats.
Habitat. On tamarind leaves and *Evodia.*

31. Dinaspis permutans, Green.

Locality. Western Ghats, 800 feet.
Habitat. On *Evodia.*

32. Diaspis rosæ, Bouché.

Locality. Bangalore (March). *Habitat.* On a wild plant and also on mango leaves.

33. Diaspis mangiferæ, Green.

Locality. Alamanda, Vizagapatam District. *Habitat.* On mango leaf. I am not quite sure whether this has not been recorded before from India.

34. Hemichionaspis dracænæ, Cooley.

Locality. Vadanapalle, South Malabar (October). *Habitat.* On areca palm.

35. Hemichionaspis chionaspiformis, Newst.

Locality. Coimbatore. *Habitat.* On wild indigo. Previously recorded from Africa.

36. Fiorinia plana, Green MS.

Locality. Coimbatore and Tinnevelly District. *Habitat.* On leaves of *Elæodendron glaucum.* The infested leaves present an ashy grey appearance.

37. Aspidiotus cydoniæ, Comst.

Locality. Bangalore and Coimbatore. *Habitat.* On shoots, stem and fruits of grape, fig and pear plants. Very probably introduced with nursery stock from Australia.

38. Aspidiotus tamarindus, Green MS.

Locality. Coimbatore. *Habitat.* On tamarind leaves and fruits. Very closely allied to *A. hederæ,* Vall. Found in company with *A. orientalis* and *Hemichionaspis minor,* Mak.

39. Aspidiotus pseudocamelliæ, Green MS.

Locality. Ittige, Bellary District (October). *Habitat.* On *Capparis.*

40. Aspidiotus cyanophylli, Sign.

Locality. Nilgiris, 2,000 feet. *Habitat.* Ceara rubber and plantain leaves.

41. Aspidiotus trilobitiformis, Green.

Locality. Vadanapalle, South Malabar (October), and Coconada, Godavari (June). *Habitat.* On *Ixora coccinea, Mimusops elengi,* and mango.

42. Odonaspis penicillata, Green.

Locality. Coimbatore. *Habitat.* On nodes of bamboo covered over by the hairs and scales of the plant.

43. Odonaspis simplex, Green.

Locality. Coimbatore. *Habitat.* On bamboo stem.

44. Gymnaspis ficus, Green MS.

Locality. Kollegal, Coimbatore 1,600 feet (May). *Habitat.* On leaves of *Ficus retusa.* The infested leaves appear rough and pale, the scales appearing as patches of minute dots.

45. Gymnaspis ramakrishnæ, Green MS.

Locality. Courtallam, Tinnevelly district. *Habitat.* On *Hemigyrosa* leaves.

46. Lepidesaphes (Mytilaspis) meliæ, Green MS.

Locality. Coimbatore. *Habitat.* On stem and shoots of Nim (*Melia*) tree.

47. Mytilaspis beckii, Newst.

Locality. Trivandrum. *Habitat.* On pepper leaf.

48. Mytilaspis retrusus, Green MS.

Locality. Dodabetta, Nilgiris, 8,000 feet (October). *Habitat.* On leaves of *Litsea whitiana.*

49. Mytilaspis pallida, Green.

Locality. Ramachandrapur, Godavari District (January). *Habitat.* On guava leaf—very few found.

50. Parlatoria proteus, Curtis.

Locality. Bangalore, 3,000 feet. *Habitat.* On orchids, *Vanda* and *Bellatulum.*

51. Parlatoria orientalis, Newstead MS.

Locality. Coimbatore. *Habitat.* On a wild bush.

52. Parlatoria mangiferæ, Marlatt.

Locality. Cocanada, Godavari District (January). *Habitat.* Inner surface of palmyra leaf-sheaths.

53. Parlatoria artocarpi, Green MS.

Locality. Chandanathode, Wynaad, 1,500 feet.
Habitat. On jak leaves.

54. Parlatoria papillosa, Green MS.

Locality. Palghat, S. Malabar.
Habitat. On jak leaf.

55. Pyrogymnaspis indica, Green MS.

Locality. Quilon, Travancore. *Habitat.* On leaves of *Veteria indica.*

56. Aonidia tentaculata, Green MS.

Locality. Quilon, Travancore. *Habitat.* On leaves of *Vateria indica.*

T. V. Ramakrishna Ayyar.

195. An unrecorded foodplant of Chionaspis vitis.

While in camp at Kollegal, Coimbatore District, in September my attention was drawn to a few mango trees exhibiting prominent white and pale yellowish patches on the leaves. Some of the leaves were completely covered with this patch and were drying up, while others though retaining the natural leaf colour had smaller patches on the surface. On closer examination it was found to be an infestation of colonies of a species of scale insect. Mr. E. E. Green, to whom I forwarded specimens, kindly identified the insect as *Chionaspis vitis*, Green. The insect has so far been recorded only as attacking *Vitis lanceolaria* and allied species, *Loranthus sp.* and *Elæagnus latifolia.* The presence of the pest on mango has not been recorded before. It is likely that the pest may become important as I found several trees in Bangalore also infested with this scale. It is not unlikely that the pest distributed itself from *Loranthus* which is very commonly found as parasitic on mango trees.

T. V. Ramakrishna Ayyar.

196. Pseudococcus (Ripersia) sacchari.

In Tanjore and probably various other adjoining districts of the Madras Presidency, paddy is subject to a specific disease known in Tamil as *Soorai Novu.* The crop shows small patches of stunted and somewhat fading plants. At the time of harvest such plants become very conspicuous, as they continue to stand erect while the rest of the crop becomes lodged, owing to the weight of the ears.

The mealy bug is found in all stages between the stalks and the leaf-sheath and later on at harvest time is specially noticeable between the stalk of the earhead and the sheathing leaf or as in many cases, where the earhead is smothered, around the earhead within the leaf-sheath. The mature female is elongate, more or less cylindrical, somewhat purplish and scantily covered with meal. Males were reared out and were delicate little objects of purplish colour. The adult female lays hundreds of small oval eggs. The active young larvæ which hatch out walk up the stem and insinuate themselves into the space between the young stalk and the sheath and grow sucking the plant-sap. The places where the bugs have been at work turn dark brown in colour. The normal growth of the earhead is checked. The grains do not develop properly and if they do, they are of an unhealthy dark brown colour. It was reported that they tasted bitter and if present in good grain they spoilt the flavour of the food when cooked.

Drought was reported to favour the development of the disease.

Certain Chalcids, a species of *Scymnus*, and an Agromyzid fly were found attacking this mealy bug at Manganallur.

Y. Ramachandra Rao.

197. Thrips as a Paddy Pest.

In *Bull. Entom. Research*, Vol. VI, Part 4, pp. 353-355 (February 1916), Mr. C. B. Williams describes as new and figures an Indian Thrips under the name *Thrips* (*Bagnallia*) *oryzæ*. These specimens were obtained on very young paddy at Madurantakam, S. India, in May, but the species also occurs at Coimbatore in August and is probably more widely distributed. It usually attacks quite young seedlings and may do considerable damage, the affected plants turning yellowish, as if scorched.

As regards control measures, in the case of irrigated paddy (which seems to be most often attacked) a little kerosine oil may be run into the seed-bed with the irrigation stream, to form a slight film on the water-surface, and the plants then dipped under this by dragging a rope or bamboo across the bed.

T. Bainbrigge Fletcher.

198. Paddy Thrips.

In different parts of the Madras Presidency young paddy—chiefly the seedlings in broadcasted fields—suffers from the attacks of *Thrips* (*Bagnallia*) *oryzæ*, Williams. It was found doing some serious damage

to paddy crops in the Madurantakam taluq, Chingleput District, in May 1915. The paddy seedlings which are badly attacked appear from a distance as though gradually drying up for want of water ; this is due to the sickly pale colour assumed by the tender shoots when they are infested with the pest. The insect is a very minute creature and found in numbers, generally inside the young shoots. It is found in all stages inside these leafrolls. Numerous shining eggs, yellowish white larvæ and the dark brown adults are all found together. The larvæ and the adults by their action on the leaf tissue produce a spotted appearance to the leaf which makes the cultivators often call this disease by names meaning small-pox. During the early stages of the infestation it is found that female insects preponderate in number. The insect was identified by C. B. Williams of the John Innes Institution, Merton, Surrey (*Bulletin of Entomological Research*, February 1916, p. 353). According to him this appears to be the first species to be recorded for the mainland of India of the genus *Thrips*.

T. V. Ramakrishna Ayyar.

199. Fabrician Types of Indian Odonata.

In the June 1917 number of *Ann. Mag. N. H.* there is an article (pp. 441-450) by H. Campion "on Fabricius' Types of Odonata in the British Museum (Nat. Hist.)," in which the following Indian species are referred to :—

(1) *Rhyothemis variegata*, Linn. = *Libellula arria*, Drury = *L. indica*, Fb., Spec. Ins., I, p. 521, no. 8 (1781). The Indian form *Rhyothemis variegata variegata* is smaller than the Chinese form *R. variegata arria*.

(2) *Neurothemis tullia*, Drury = *Libellula equestris*, Fb., Spec. Ins., I, p. 523, no. 20 (1781), erroneously described as from Africa.

(3) *Crocothemis serrilia*, Drury = *Libellula ferruginata*, Fb., Spec. Ins., I, p. 521, no. 11 (1781), erroneously described as from Cape of Good Hope.

(4) *Sapho ciliata*, Feb., Spec. Ins., I, p. 528, no. 3 [*Agrion*], described from Coromandel, is really from Sierra Leone.

(5) *Mecistogaster linearis*, Fb. (1776). The type of this cannot now be traced and in its absence it is impossible to say precisely what Fabricius' *Agrion linearis* may be. It was described from India from material in the possession of Dr. Fothergill.

200. Pseudagrion rubriceps in the Khasi Hills.

Pseudagrion rubriceps was originally described by Selys from Java in *Bull. Acad. Belg.* (2), XLII, 510 (1876), and its female was described by the same author in *Ann. Mus. Genova* (2), X, 515-516 (1891), the range of distribution of the species being given as Java, Burma and India. Laidlaw (*Rec. Ind. Mus.*, XIII, 24 (1916), f. 2) has lately recorded it from Calcutta and Major F. C. Fraser has taken it at Poona.*

At the end of October and beginning of November 1918, I found this species in small numbers along the shores of the Ward Lake at Shillong, where its occurrence was curiously limited to two non-contiguous parts of the shore of the lake. In life this is a very handsome species, the blue abdominal markings of the male being very vivid and the orange frontal portion of the head very conspicuous, especially when this dragonfly hovers on the wing facing the observer. The flight is swift and when disturbed the insect often hovers motionless in one place over the water or even darts backwards in a straight line. The male grasps the female around the neck and flies with her in the usual Cœnagrionid manner. A female, grasped by the male, was observed ovipositing on a half-submerged twig which was floating freely on the water.

T. Bainbrigge Fletcher.

* Since this Note was sent to press I have also found it at Nagpur in December 1918. [T.B.F.]

A Malarial Parasite in the Blood of a Buffalo.

[*Received for publication on 19th March, 1919.*]

REFERENCE to the literature would appear to indicate that up to the present the occurrence of malarial parasites in the blood of ruminants has not been recorded except by Bruce, who found two antelopes infected in Nyasaland in 1913. This observation is published in the *Proceedings of the Royal Society*, Series B, Vol. 87, 1914. It is therefore desirable that a description, although incomplete, of a parasite found in an Indian buffalo should be placed on record.

Reference to Bruce's description of the parasite found by him in the duiker shews that that organism is morphologically quite distinct from the one described in this note.

The parasite was found in blood smears taken from a plains buffalo after death. Unfortunately it is impossible to do more than describe the morphology of the organism, as the animal died on the day fixed as a holiday to celebrate the signing of the armistice (Dec. 9th*) and the blood smears of the animals dying on that day were not examined until the following morning. As there were no grounds for suspecting any special infection, the carcase was destroyed on the day the animal died.

The buffalo was a male, four years old. It was bought in Bareilly in July 1918, and reached Muktesar early in August. After a period of quarantine it was taken into the sheds as a serum-maker. On August 23rd it was inoculated simultaneously with 0·5 c.c. of defibrinated virulent blood and 39 c.c. of anti-rinderpest serum (*i.e.*, 1 c.c. per 10 lb. body weight). The animal shewed a moderate temperature reaction but did not develop any other symptoms of rinderpest. The temperature fell to normal (about 38°) on the 11th day after inoculation, but it remained rather unsteady for several days. On September 12th the animal was bled for serum.

On September 14th it received its first hyper-immunizing dose of virulent blood. There was no distinct reaction, but there was a sudden rise and fall of temperature from 37·7° to 40° and back to 37·7° between the morning of the 22nd September and the morning of the 24th.

* The lateness of this date is accounted for by the fact that paucity of European staff and isolation made it impossible to organize any celebration rapidly.

For ten days after this the temperature remained very steady, and the animal was bled for serum on the 24th and the 26th.

The temperature fell on the evening of October 4th to 37·2° and the following morning it was 36·8°. On the evening of October 5th it had again risen to 39·4° and it remained at about this level till the evening of October 10th.

The animal was again injected with virulent blood on October 9th.

The temperature remained normal, and the usual routine of injections and bleedings was carried out until November 8th. The animal had been bled on the morning of this day, and in the evening its temperature had risen to 40·3°. It had fallen to 39° on the following morning. On the evening of the 10th and the morning of the 11th there was another slight rise of temperature from 38·6° to 39·6°.

From this until December 4th, the temperature remained very steady, shewing slight rises only on the 15th, 25th and 26th November.

The animal was injected with virulent blood on November 23rd and bled for serum on December 3rd. From the evening of December 4th, when the temperature was 38·9°, there was a rapid fall until the morning of December 6th, when it was 36·1°. By the evening it had risen to 39·0°.

The animal was due for bleeding on this date, but as its temperature in the morning was so low, bleeding was not carried out.

On the morning of December 7th, the temperature was 38·8°, but during the day it fell rapidly, and by the following day it was 35°. The animal survived during the day but died during the night of December 8th.

From this it will be seen that there was no regular periodicity of fever.

Examination of the films shewed that there was present in the blood what appeared to be a complete series of types of parasite, in successive stages of development.

For the purposes of differential counting it was possible to divide them into three groups representing the most prominent members of the series. Forms intermediate between the three main groups were classified with that group to which they most closely approximated morphologically.

The three main types may be called :

(*a*) Small forms.

(*b*) Large forms.

(*c*) Dividing forms.

The immense majority of the parasites were intracorpuscular, but organisms belonging to each of three groups were found free in the plasma. For this there is a rational explanation which will be seen when the morphology of the parasites is described.

(*a*) *Small Parasites* * (Plate I, figs. 1 to 7). The smallest parasites found were distinctly piroplasm-like in appearance. They shewed a small rounded or slightly irregular piece of chromatin (occasionally two pieces) and a small amount of cell body, which in some appeared to be solid and in others to contain a vacuole. They varied somewhat in outline, but the majority were rounded, oval, or pear-shaped, and measured about 1 micron in their greatest diameter. Between these small parasites and the next group—the large parasites—there was a series of organisms of gradually increasing size. (Plate I, figs. 8 to 13.)

Apart, however, from the increase in size, there were other morphological details distinguishing them from the smallest organisms.

As the organisms increased in size, the number shewing a central vacuole rapidly increased and the vacuole itself became much larger. The increase in the size of the vacuole caused the chromatin to be pushed to one side.

Two pieces of chromatin could be distinguished in some of these organisms.

In organism measuring about 3 microns and upwards in diameter, a new morphological feature could be found in the presence of a small grain of deep brown pigment within the cytoplasm. From this stage up to the typical, large parasite, the parasites increased in size and the amount of pigment present was progressively larger.

(*b*) *Large Parasites* (Plate I, figs. 14 to 17) were for the most part circular in outline, but a few oval forms were found; the latter were possibly distorted in spreading the film.

The maximum diameter attained by the large parasites was about 6 microns. Organisms of this size differed somewhat among themselves in appearance.

In the majority of the large parasites there appeared to be a vacuole of considerable size, occupying a central position in the cytoplasm. In these the chromatin was pushed to one side and formed a crescent-shaped mass along the margin of the cell. In others the whole body of the parasite took the blue stain (Romanowsky) although the staining was almost invariably somewhat fainter in the centre than at the periphery.

* All references to illustrations in the text refer to the coloured plate. A separate description is given for the photographs which are published in support of the drawings.

The chromatin was either in a single piece or in two pieces, and it was always somewhat loose in texture.

In these large parasites the pigment deposit was a striking feature. In some of the organisms, the granules were collected together into a single mass, and in others they were scattered through the cytoplasm. The individual granules were invariably rod-shaped, and gave the impression of being crystalline.

The next stage of development in these parasites appeared to be a preparation for division.

(*c*) *Dividing Forms* (Plate I, figs. 18 to 28). In parasites preparing to divide, the chromatin became spread out through the cell body in the form of fine interlacing filaments.

This was followed by a process of what may be termed condensation of the chromatin at a number of places among these filaments, leading to the production of a number of discrete chromatin particles embedded in the remains of the chromatin "web."

Dividing forms. These differed from the foregoing in that the interlacing filaments of chromatin had entirely disappeared, leaving only the discrete chromatin particles scattered through the cell body. These numbered from seven to fourteen. The next stage was the division of the cytoplasm into a number of pieces, each containing a fragment of nucleus. About the same time the enclosing red corpuscle appeared to have burst.

The small parasites thus formed were set free to invade other cells.

The pigment granules persisted throughout and were set free in the plasma with the new brood of parasites.

In a number of places in the film, leucocytes containing granules of pigment were found, and in a few instances leucocytes appeared to have ingested entire parasites.

Figs. 29 to 34 on Plate I shew some irregular forms of the parasite, and Fig. 35 shews pigment granules within a leucocyte.

Reference has already been made to the fact that parasites of all three types were found free in the plasma. The rupture of the corpuscle containing a parasite undergoing division is sufficient explanation for the presence of dividing forms and small parasites free in the plasma.

The presence of large forms free in the plasma is also explained by the rupture of the containing cells owing to the pressure put upon them by the presence of the parasite. Cells which contained large parasites were found measuring up to 14 microns in diameter, and it is reasonable to suppose that cells distended to this extent would be very liable to burst.

Multiple infection of cells. While in the majority of cases a single blood corpuscle contained a single parasite only, numerous examples were found of multiple invasion. These cases of multiple invasion were usually due to small parasites. Two, three, four and five small parasites were found in a single cell. This indicates that in such cases the multiple infection was actually multiple invasion and was not due to small parasites produced by division failing to escape; an additional point in favour of this view being that no pigment granules were found in such corpuscles.

There were also found cells containing two parasites of a size intermediate between the small and the large, and also cases in which a large and a small parasite occupied the same cell.

Extent of the blood invasion. An enumeration of the blood corpuscles shewed that 1·6 per cent. contained parasites.

Differential count of the parasites. As already stated, in making a differential count of the parasites, they were divided into three groups, (*a*) small, (*b*) large, and (*c*) dividing forms. The organisms intermediate between these types were apportioned to the group to which they most closely approximated. Thus, types between the small and large forms were assigned to one or other group, taking size and the presence of pigment into consideration.

In making the examination of the dividing forms, all parasites which shewed the preliminary formation of the chromatin "web" were considered as dividing forms. Working on these lines, it was found that the small forms numbered 35 per cent., the large forms 55 per cent., and dividing forms 10 per cent. of the whole number.

Changes in the blood. Apart from the presence of the parasite, the blood shewed many of the changes associated with anæmia, normoblasts, megaloblasts, anisocytosis, polychromasia, and punctate basophilia which were present to a marked degree.

It is possible that the changes in the blood-corpuscles may have been due to some extent to the withdrawal of 2,200 cubic centimetres of blood for serum on December 3rd.

Should the parasite here described prove to be a new one, I would suggest the name *Plasmodium bubalis* for it.

I am indebted to Babu Duni Chand, Artist on my staff, for the very accurate coloured drawings of the parasite and also for his assistance in obtaining the photo-micrographs.

Description of Plate I.

Figs. 1 to 7.—"Small" parasites.

Fig. 1.—Small parasite which has apparently just invaded the corpuscle.

Fig. 2.—Double invasion by small parasites. Vacuoles appearing in the cytoplasm.

Figs. 3 to 5.—Shewing the crescent-like shape of the chromatin.

Fig. 6.—Two distinct pieces of chromatin present in the parasite.

Fig. 7.—Double invasion by parasites of different ages. The larger shews small pigment granules.

Figs. 8 to 13.—Parasites intermediate between small and large forms.

Fig. 8.—Parasite contains a large vacuole. Pigment and chromatin peripherally placed.

Fig. 9.—Double infection with two parasites of similar age.

Fig. 10.—Vacuolated parasite with pigment collected together in a single mass.

Fig. 11.—Pigment centrally placed and in the form of two distinct rods.

Fig. 13.—Double invasion of a blood corpuscle by an intermediate and a small parasite. The larger parasite is not vacuolated.

Figs. 14 to 17.—Large parasites.

Fig. 14.—Double invasion of a blood corpuscle by a large and a small parasite. The large parasite shews the loose-textured chromatin and scattered pigment granules.

Fig. 15.—An extra corpuscular large parasite with loose-textured chromatin and scattered pigment granules, all of which are rod-shaped.

Fig. 16.—Closely resembles Fig. 15, but is intracorpuscular.

Fig. 17.—Large vacuolated parasite.

Figs. 18 to 28.—Dividing forms.

Fig. 18.—The formation of the chromatin "web."

Fig. 19.—Commencing condensation of the chromatin.

Figs. 20 and 21.—Condensation of the chromatin nearly complete.

Figs. 22 to 26.—Various types of dividing parasites.

Figs. 27 & 28.—Dividing forms which have escaped from corpuscles and are on the point of splitting into a number of small parasites.

Figs. 29 to 34.—Various irregular forms encountered in the specimen.

Fig. 35.—Rod-shaped pigment granules enclosed in a leucocyte.

×1,500.

A malarial parasite in the blood of a buffalo.

Description of Plate II.

Figs. 1 to 3.—Double and single invasions of corpuscles by small parasites.

Figs. 4 to 7.—Parasites intermediate between small and large forms.

Fig. 4.—Parasite not distinctly vacuolated.

Fig. 5.—Parasite distinctly vacuolated. Chromatin and pigment disposed at the periphery.

Fig. 6.—Double invasion by two intermediate parasites.

Fig. 7.—Double invasion by a small and an intermediate parasite.

Figs. 8 to 14.—Large parasites.

Fig. 8.—Double invasion by a large and a small parasite.
The large parasite is distinctly vacuolated.
The pigment is collected into an oval mass at one side and the chromatin forms a crescent-shaped mass on the other.

Fig. 9.—Closely resembles Fig. 8.

Fig. 11.—A large parasite shewing a bundle of pigment rods and a single mass of rather loose-textured chromatin.

Fig. 12.—Large non-vacuolated parasite with two rounded masses of loose chromatin and a number of scattered pigment rods.

Fig. 13.—Closely resembles Fig. 12, but the two masses of chromatin are more distinctly visible.

Fig. 14.—Large extra corpuscular parasite.

Fig. 15.—Four large parasites in a single field. The uppermost resembles Fig. 13, and the second and lowermost resembles Fig. 11. The remaining one which is a little distorted shews the first stage in the process of division. The chromatin is beginning to spread through the cytoplasm to form the chromatin "web."

Figs. 16 to 20.—Dividing parasites.

Figs. 16 & 17.—Shew the chromatin spreading out in the form of interlacing filaments.

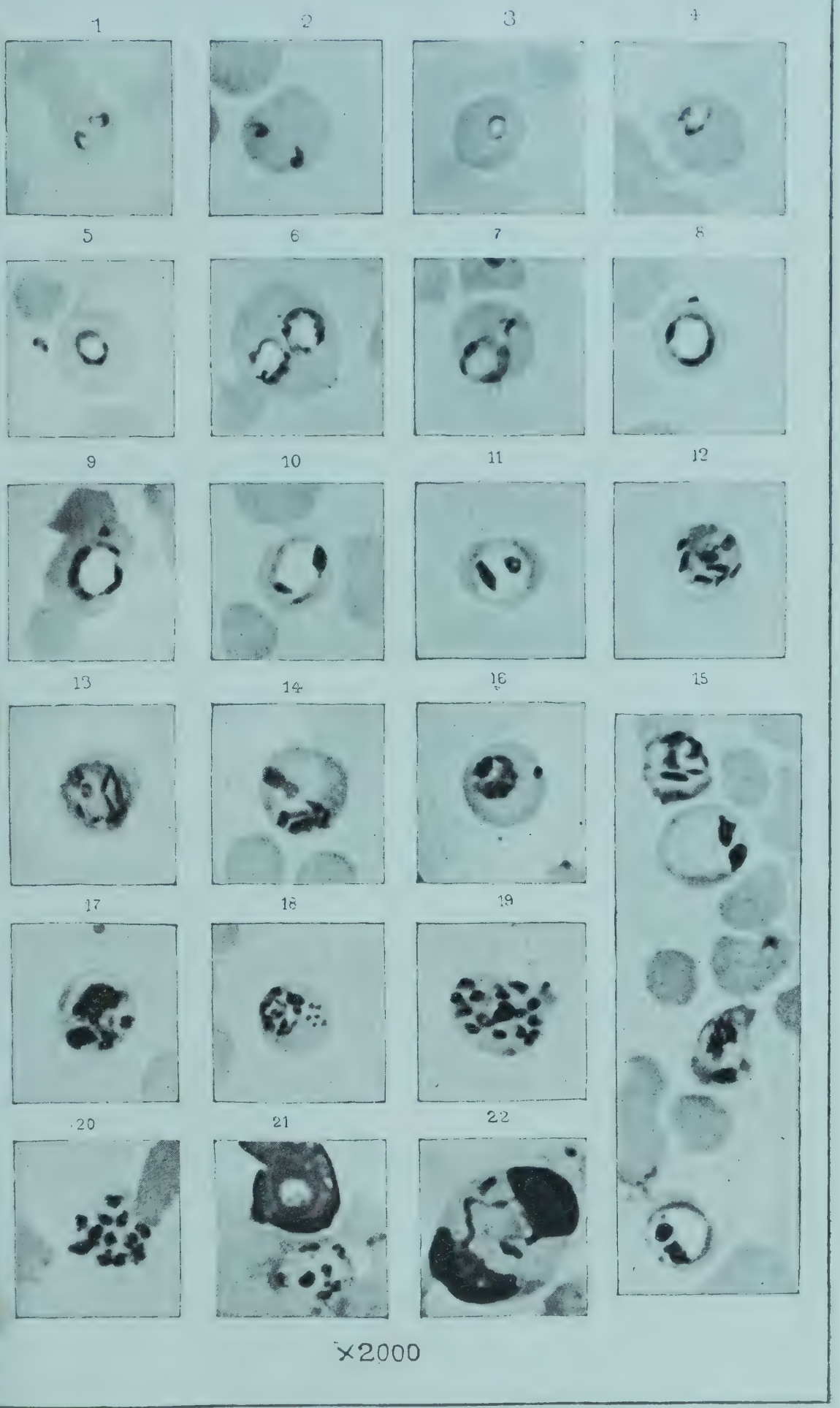
Fig. 18.—The process of condensation of the chromatin has started.
Three small parasites are present in the corpuscle at the same time. (These are not quite in focus.)

Fig. 19.—A parasite ready to fragment but still enclosed in a red corpuscle.

Fig. 20.—A parasite free from its corpuscle becoming fragmented.

Fig. 21.—The remains of a dividing parasite which has been ingested by a leucocyte.

Fig. 22.—Pigment granules within a leucocyte.



A malarial parasite in the blood of a buffalo.

Blocks by Govt. Photozinco. Office, Poona.

VIEWS ON THE RECLAMATION STATION, DAULATPUR, SIND.

Notes on Practical Salt Land Reclamation.

[*Received for publication on 21st May, 1919.*]

CHAPTER I.

Alkali Land Reclamation.

THE question of alkali, *kalar*, *reh* or *usar* land has received a certain amount of attention in India from agricultural and irrigation authorities, but the subject is bound to force itself into greater prominence as modern perennial irrigation works extend.

Alkali land is so called when it contains a greater or less amount of water-soluble mineral salts which exert a harmful influence on vegetation. The question is often bound up with water-logging and leakage from irrigation canals.

Arid land all the world over, on which the annual rainfall is not sufficient to leach the soluble salt out of the surface soil, suffers from damage due to alkali.

The alkali damage is frequently not visible for some years after the opening of a new canal system, and then the water or want of silt is blamed.

While the chemical aspect of reclamation is of great importance, the practical technique is of still greater importance. This is frequently lost sight of in India, and where alkali problems crop up it is a mistake to consider that these can be solved solely by laboratory findings.

A brief survey of practical reclamation work in Egypt and India should be of value in order to give a definite idea of the most promising lines of work.

Without a soil survey it is impossible to state what area of land is affected in India. Sind is, however, probably in worse case than any other part of India, having an average annual rainfall of under 10 inches. In the Punjab the damage caused by alkali conditions is probably less and still less in the United Provinces.

CHAPTER II.*

Alkali Conditions in Sind.

In arid America, field parties of the Bureau of Soils have mapped the soil and studied the alkali conditions of a number of typical irrigated districts covering over 3,000,000 acres of land. They have found that on the average about 13 per cent. of the irrigated lands examined contain alkali in sufficient quantities to be either harmful to the growth of crops or to prevent entirely profitable cultivation. Sind has 30,000,000 acres, half of which are scheduled as cultivable and 4,000,000 are cultivated annually under irrigation. It is not possible to say what the per cent. is in Sind of alkali or *kalar* land without a proper soil survey, but it would probably be found not to be under the above percentage.

In 1916 the Government of India called for report from experienced local irrigation and revenue officers regarding the prevalence of *kalar* or alkali in Sind, and the following is a resumé of their opinions :—

Mr. H. C. Mules, Collector of Karachi :—

" In former days grants of *kalar* land were made on very easy terms with a view to their reclamation. They were thoroughly washed, *i.e.*, flooded, and the water held on them by ' bund ' for a year or two, then rice was grown. The finest rice lands in Sind, producing a quality of rice known far beyond the boundaries of the province, are known as the ' mail ' in the Larkana District, near Gogharo. These lands were formerly rank bad *kalar*. Some very bad *kalar* lands were granted many years ago on a reclamation lease to the late Seth Ramchand of Khorewah, a very enterprising zemindar who in course of time obtained excellent results. There are concrete instances but the same kind of thing is going on all over the country on varying scale.

" A very striking instance of the movement of subsoil salt induced by the action of irrigation channels or floods is to be seen at Jacobabad. For one who remembers Jacobabad in the early seventies the change is very remarkable. Then the land in cantonments was sweet, the wells were sweet and the water good, the gardens were remarkable for their luxuriant growth and the vegetables raised therein were every bit as good as the best English vegetables. Now the whole place is salt, the wells are many of them useless, and the gardens have died away. But you have only to ride beyond the limits from which floods were excluded to find the lands which were flooded, washed and subsequently irrigated,

* This chapter is reproduced from the *Bombay Department of Agriculture Bull. No. 64 of 1914.*

bearing splendid crops. And I may say that hundreds of villages have been similarly affected. It is quite common to find the village site rank *kalar* and the surrounding fields sweet and productive.

" It will, I think, be found that the way to eradicate salts is to wash them out. Wherever there is good head of water and a reliable supply this is possible. But, of course, it is essential to drain off the water used for the washing; take the instance of ' puncho ' water. It is by no means uncommon to hear officers speak of this system of passing off water after it has stood on the rice for a little while as a waste of water. It is not so; the cultivators know perfectly well that the water gets sour and must be passed away before it becomes so and injures the crop. Therefore depressions and low grounds are used for the reception of ' puncho pani ', and the crops receive constant fresh supplies. In the same way it is necessary to pass away and renew water used for washing the land."

Mr. G. E. Chatfield, Colonization Officer, Jamrao Canal :—

" Salt or *kalar* land is to be found in the Jamrao tract, as in the rest of Sind, in large quantities. The salts are of different kinds and have different effects, some being almost harmless and others noxious to cultivation, some easily soluble in water and others not so. Native cultivators call them by different names (' white,' ' red,' ' black ' *kalar*) and have hazy knowledge of their effects.

" In the Jamrao tract there are large stretches of *kalar* lands, which are regarded as uncultivable. Much of this land would be cultivated were it ' flow ', but owing to the tendency of *kalar* to seek the highest lands such large *kalar* patches are usually ' lift.' Besides these, there are small sporadic patches of *kalar* scattered over the whole tract, so closely that scarcely any village, however excellent the soil, is without them. From a comparison of the land which is under perennial irrigation with the surrounding land, I should say that these patches had always been there and that irrigation is not responsible for the appearance, though it increases their size. It is difficult to observe sporadic patches of this kind, but from the general complaints of cultivators as well as from what I have actually observed in certain parts of the tract (*e.g.*, near Mirpurkhas and in Dehs 87, 88, 89), it seems that in many places *kalar* is spreading with irrigation (percolation, on the other hand, brings up *kalar* where none was previously found, and the land on either side of the canal minor and water course is almost invariably rank *kalar* for a considerable distance). Against this I must add that in many villages the *kalar* is certainly being washed down out of the soil by means of irrigation.

" In comparing Jamrao lands with those on inundation canals it must be remembered that the latter are generally lift lands or rice lands ;

for when the Sindhi can get flow he will generally grow rice. In rice lands *kalar* is a matter of small importance, and in lift villages the water is generally sufficient for a mere fraction of the whole area, which fact enables the zemindar to pick and choose his land. Villages on the Central Hyderabad canals contain many waste numbers which are not taken up on account of *kalar* but which would be taken up were these villages brought upon the Jamrao canal.

"About the causes of the appearance of *kalar* I have little to add. In lands which have never been under irrigation it is nearly always present, though in varying quantities, and with irrigation it sometimes increases and sometimes decreases according to the nature of the subsoil. The only remedy known in Sind is to wash down salt into the subsoil with heavy waterings. For this purpose it is usual to start with some crop which can stand a certain amount of *kalar*. The crop which is preferred is rice; some of the inferior millets (*e.g.*, *sao* *), wheat and *jambho* † are also grown in such cases.

"I cannot record any very brilliant successes in the reclamation of land on the Jamrao, though some lands have undoubtedly been improved by cultivation in Digri and Jamesabad.

"Rice is undoubtedly well suited to *kalar* lands and the heavy flooding which it requires improves the land immensely. This crop is forbidden in the Jamrao and could not be permitted without a great loss of revenue. Neither is it a remedy suited otherwise to the tract; for while heavy flooding sweetens the land flooded it causes the salt to rise in the adjacent lands. Moreover, the worse stretches of *kalar* are usually too high for flow irrigation.

"In rice districts, such as the south of Hyderabad, of which I had formerly charge, it is only the worse kind of *kalar* which is regarded as uncultivable. But where much salt was present in the soil it was found necessary to change the water very frequently. This was effected by letting out the water from the cultivation into the ditches and depressions which surrounded the fields; unless this was done frequently the crop was believed to suffer.

"Much land on the Jamrao is undoubtedly deteriorating under irrigation and becoming *kalar*. Much land has not been taken up because it contains *kalar*. Much that has been taken up is not paying for the same reason. The recent rise of cultivation on the Jamrao is chiefly due to the giving out of fresh lands in 1905, and in any case would scarcely affect the question."

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* *Panicum Crus-galli.* † *Eruca sativa*

Mr. G. McC. Harrison, Superintending Engineer, Indus Left Bank Division :—

"There appear to be three kinds of alkali known in Sind :—

"I. *Rapri kalar*, or chloride of sodium, from which salt was manufactured before for use in Sind. Oil-seeds will grow on lands infiltrated by this kind of alkali.

"II. *Bhanothi kalar*. This is generally found where old village sites once stood, or where leaves and other debris decay. This is probably sulphate of sodium from which Glauber's salt was once manufactured near Sehwan old fort. Such *kalar* is collected and used as manure for crops. Its area is insignificant.

"III. *Dudh kalar*, or carbonate of sodium, is seen in arid high level lands. Rice can be grown on these lands if there is plenty of water."

It would undoubtedly be of the greatest use if an alkali map of Sind were prepared. In the tract of the proposed Rohri-Hyderabad canal such a map will be extremely useful ; here there are no doubt isolated portions of land which owing to alkali are useless for any or only rice cultivation. In such portions minor canals or distributaries could be left out altogether or designed for rice cultivation.

Mr. F. St. J. Gebbie, Executive Engineer, Jamrao Canal :—

"For some years past there have been vague complaints that owing to the evil qualities of the Jamrao water all the land is turning to *kalar*. I have asked many zemindars to show me land which, before the Jamrao was constructed, had no *kalar* in it and which has now become unculturable, but no one has yet done so.

"It is true that there is now a much larger area of *kalar* land in the Jamrao tract than there was before the canal was constructed ; but that is due to the large area of what was formerly waste and is now being cultivated. A good deal of this waste land was *kalar*, but the *kalar* did not become visible till it was irrigated.

"I know of no remedy for *kalar* except careful cultivation and manuring. I have heard a great deal of growing rice to wash out the *kalar* but I have still to see a case in which this has been done and any other crop except rice grown on the land afterwards. The Sindhi in these parts is a great believer in this system ; but it seems to me he makes such a strong point of it rather to try and get permission to grow rice than with any idea of really washing the *kalar* out of the land. All Sindhis are anxious to grow rice because it suits their lazy slipshod methods of cultivation.

"Provided that the people are satisfied with the supply of water as fixed by Government, *viz.*, one cusec for every 300 gross acres, there is no objection to allowing them to grow rice on the Jamrao ; but they

will not be satisfied with this. They say that rice wants a constant supply and they cannot be given this under existing conditions. With the outlets and water courses as they are, the only efficient method of distributing water fairly to every one in a village is by 'share lists' as is done in the Punjab. But if any man is to get water constantly a share list cannot be prepared and he must get water at the expense of other cultivators in the village.

"Since the Jamrao was constructed about 57 per cent. of the culturable area of village No. 18 has been cultivated annually and practically all by flow; but no *kalar* has appeared because there never was any in the soil. On the other hand, village No. 38, in which about 20 per cent. area is cultivated all on lift, is beginning to show *kalar* in many places."

In summing up the Commissioner in Sind stated :—

"The reports submitted scarcely give an adequate idea of its extensive prevalence throughout the province, owing to the non-existence of any statistics on the subject. Even materials for a rough estimate of any degree of reliability are not available. It is hardly possible to say more than that the occurrence of saline area, in every gradation from isolated patches to continuous barren tract many miles in extent, is one of the most familiar features in Sind; and the gravity of the evil is to be measured, not only by the diminution in the cultivated area and the injury to crops occasioned in localities where attempts are being made to control it, but also the permanent exclusion from cultivation of large areas of otherwise valuable lands."

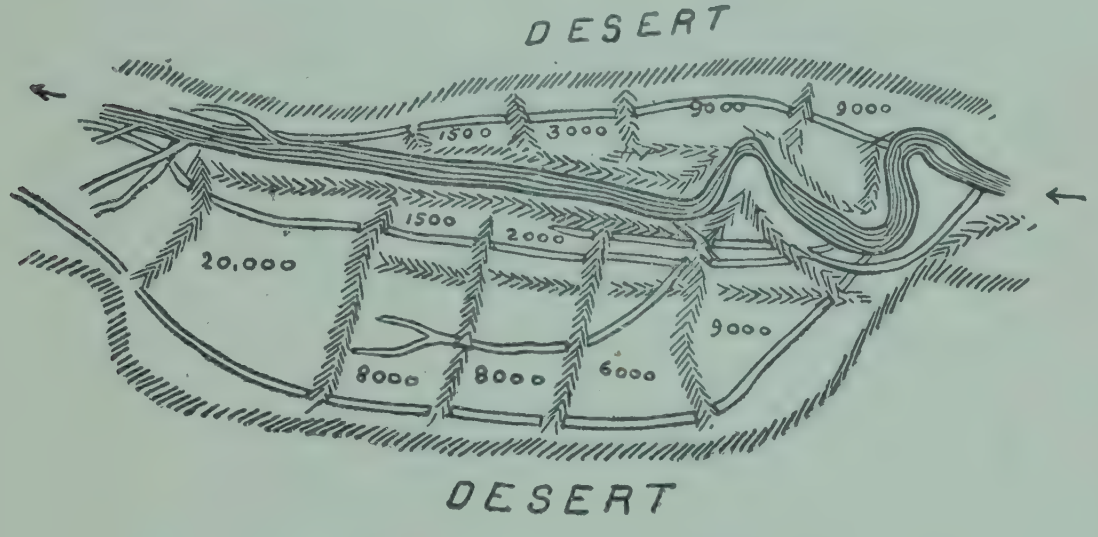
CHAPTER III.

Reclamation Work in Egypt.

Egypt with a cultivated area of about 6 million acres and with a population the density of which is one per acre, is only a fraction of the size of an Indian province. As the land is very productive, the agriculture and irrigation afford most useful study for the irrigated portions of North-Western India.

Formerly only the basin system of irrigation was practised in Egypt. This method consists of flooding the land in the basins to a depth of several feet at High Nile about the second week in August, and then when the river level sinks in October in letting the water back into the river.

The plan shows clearly a system of basins with the channels to fill and empty and the 'bunds' necessary. When the water is emptied the greatest care is used to prevent too rapid an escape which would scour out the new silt deposited.



A system of basins in Upper Egypt.
The figures show the area in acres of the different fields composing the system.

C P

With the basin system only one crop can be taken per year and cotton cultivation is not possible. When the basin system was practised there was no damage from alkali. The large amounts of water used washed the salts well down into the subsoil.

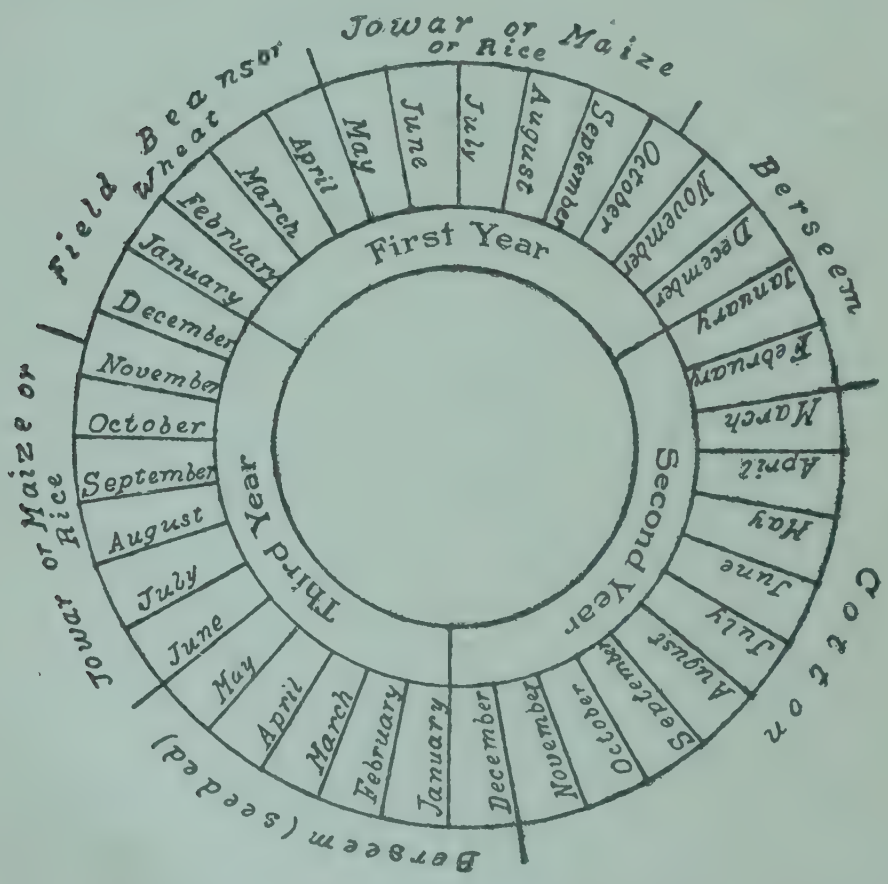
Damage from alkali began to be felt when perennial irrigation canals were substituted for the basins, but as a rule this was chiefly experienced in the low lands in the north along the borders of the Mediterranean. Land which is under the 6-foot contour line is apt to show signs of salt more especially along the large drains which run full at the time of high river. The northern land gradually tails into the great lakes, Lake Edkou, Lake Burlos and Lake Menzaleh, which lie between Alexandria and Port Said. These lakes communicate with the sea and the bordering land gets flooded with sea water especially during northerly winds.

Lake Aboukir, one of the smallest of these lakes, has been reclaimed and as most of the reclamation work in Egypt is similar in character, a study of the history and methods of the work is of interest.

The other lakes represent an area of over a million acres. When this area is taken in hand after provision is made for the necessary irrigation water by works in the upper sources of the Nile, a tract of excellent cotton and general agricultural land will become productive. This work would be an excellent field for the new Empire Development Board. The agricultural population of Egypt would rapidly take up the land when in a fit state at very remunerative prices. There is no harder working and painstaking agriculturist than the Egyptian "Fellah" when he is working on his own land and for himself.

The high production of agricultural land in Egypt is remarkable, crop succeeds crop and there are no fallows. Yields of seed cotton of 2,000 lb. per acre are nothing remarkable. A rough method of estimating the return of agricultural land used to be to multiply the average yield of the land in 'kantars' (say 315 lb.) of seed cotton by £15. There is land averaging up to 10 kantars which thus would be worth £150 per acre.

An example of cropping of good agricultural land spread over 3 years is as follows:—



Typical 3-year rotation.

It will only be by the adoption of suitable intensive rotations and the largely increased use of leguminous fodder crops and keeping and feeding increased number of live stock that the yields of irrigated land in North-West India will approximate more nearly to those in Egypt. At present the average yields per acre in the Punjab canal colonies, especially on the older colonies, are very small and evidence seems to point to the fact that yields are decreasing. The various Agricultural Departments have taken the matter up seriously and their recommendations together with the necessary co-operation of the Irrigation Department will have effect in time. The Board of Agriculture in 1917 recommended combined action for the different provinces affected by means of a central research station, and this would be the best solution of the matter which is of the greatest importance from every point of view.

CHAPTER IV.

Aboukir Company's Reclamation Work.

The reclamation of Lake Aboukir was started by an English Company in 1888. Some 30,000 acres were taken up on the site of the lake of that name about 10 miles from Alexandria. The land was a dry salt plain in the hot weather and a shallow salt lake in winter. As the soil was a sticky black clay and seemingly very impervious to water many doubted the feasibility of the reclamation. The percentage of soluble salt in the first three feet averaged over 6 per cent.

The first step was the provision of a sea-wall to prevent any sea water from flooding the land, especially during the period when northern winds blow across the Mediterranean.

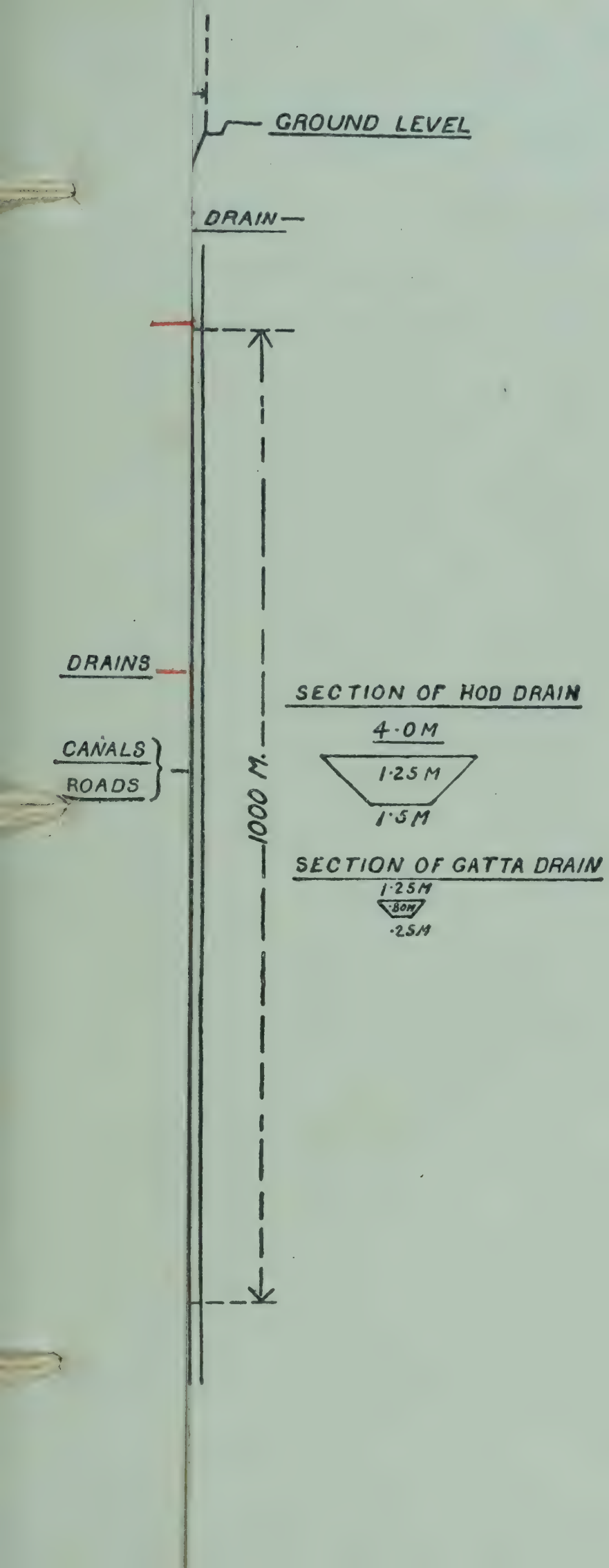
Then the canalization was taken in hand. The main drains and canals were dug and the minor earth-work completed for those blocks which were first started. The land being below sea level the drainage water had to be pumped up into the sea. The object was to keep the subsoil water level at a minimum depth of 2′ 6″ below surface level. The main drains had to be of sufficient depth to get a flow from the minor drains.

The Company had many difficulties at first, and it was only after years of experience that the technique was perfected and reliable methods standardized that the reclamation work became successful and the Company enabled to pay large dividends which it has done ever since.

The drainage pumps gave difficulty at first; the pumps at the ends of the main drains would suck dry before the water in the minor drains has begun to flow. This difficulty was got over by the provision of drainage outlets into Lake Marioties the level of which was kept down by a Government pump installation to 8 feet below sea level to provide drainage for the surrounding country.

The ' gatta ' or plot of 2 feddans (1 feddan=about 1 acre) is the unit of canalization. The series of plots is the ' hoshey ' and the ' hosheys ' make up the ' hod ' or village. Each ' hod ' is treated separately for labour, management and account purposes. Each ' hod ' has a foreman or ' holi ' responsible for all matters in the ' hod ' and an ' esbah ' or village is built in a convenient site. This ' esbah ' is usually stone built and contains ' magazines ' or stores, court for cattle and workmen's rooms and threshing floor.

The plan and section of a typical ' hod ' is attached and clearly shows the principles of the canalization.


GROUND LEVEL
DRAIN
DRAINS
CANALS
ROADS
1000 M.
SECTION OF HOD DRAIN
4·0M
1·25M
1·5M
SECTION OF GATTA DRAIN
1·25M
·80M
·25M

The first work after the earth-work is finished is levelling. This is done by wooden scoops working after ploughs. It is very important work and the plots must be made quite level. Permanent bunds may be made in the centre of the plots if there is much difference in level between the two ends. Levelling must be carefully supervised. There is no operation in which more money can be wasted. These scoops or 'khasibehas' have been described in Pusa Bulletin No. 73 on "New Agricultural Implements for India."

As the cost of levelling varies with the square of the distance of the 'lead,' short leads should be the rule.

After levelling water is let into the plots and the final levelling given by a long board drawn by cattle through the water.

Water is only allowed for flooding purposes during high Nile. It is however essential that while washing the plots should be kept full, *i.e.*, 3-4″ deep. If the plots are simply irrigated and then allowed to dry they get worse than they were before, owing to evaporation. If the plots are kept properly full the salt on solution is washed into the subsoil and goes off by the drains. There is no surface washing and any case of broken bunds by which water can get direct into the drains is strictly against rules. Also each plot has a separate inlet for the irrigation water and no plot receives water from another plot. After washing for a couple of seasons the plots begin to sweeten up. It is however sometimes necessary to run a drain up the middle of each plot if the improvement is slow. The first crop sown is 'denebah' (*Panicum Crus-galli*) which is an useful fodder. When the land can grow really good berseem (*Trifolium alexandrinum*) the cultivators will buy or rent it eagerly.

Some of the land is sold to the actual cultivators on ten yearly instalments. The instalments are calculated to be equal to the value of the yearly cotton yield. The cultivator has the other crops to live on in the meantime, and as he eventually becomes the owner of his land the system is satisfactory for both sides and works well in practice.

The above is only a brief outline of the work, it is in fact a highly specialized branch of estate management and requires a combination of agricultural and civil engineering.

The cost of the reclamation work depends on special circumstances; it may vary from £5 to £15 per acre.

Typical analyses of the soil are appended. It may be noted that all observers dwell on the fact that the soil in actual practice is much more pervious to water than would be supposed by the mechanical analysis.

There are a number of other reclamation works on much the same principles, they have not all been successful; there is the Kom-el-Akhdar concern on which a French Company is said to have spent a

million pounds on 10,000 acres without achieving success. The soil was not different from others which have been successfully reclaimed. It is probable the failure was due to Western methods being adopted without modifications necessary to the East.

Considerable expectations were based on tile drainage for reclamation in Egypt but only small works have been carried out so far. The advantages of this method are the speed and thoroughness with which the work can be completed and the saving of actual land.

The disadvantages are the cost and the fact that the salt gradually destroys the tiles. There is also the danger of the washing water getting direct entrance to the drains through cracks and holes which would cause great damage. The saving of land is more apparent than real as after the land is reclaimed many of the drains can be filled in.

A point of great practical importance is that the land should be properly reclaimed before it is given out to cultivators. If the salts are not properly washed down into the subsoil before ordinary crops are grown the only result is loss to all concerned.

Analyses of soils from Lake Aboukir, made by Breazeale of the American Bureau of Soils, from the United States Department of Agriculture, Bureau of Soils Bulletin 21 :—

Constituent	7544, 0 to 12 inches	7545, 12 to 24 inches	7546, 24 to 36 inches	7538, 0 to 6 inches	7539, 0 to 12 inches	7540, 0 to 6 inches	7541, 6 to 12 inches	7,542, 0 to 6 inches	7543, 6 to 12 inches
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Ions :—									
Calcium (Ca)	15·45	2·68	1·44	13·46	10·12	17·18	9·72	9·16	0·0
Magnesium (Mg)	Tr.	Tr.	Tr.	Tr.	3·73	Tr.	11·87	Tr.	Tr.
Sodium (Na)	17·63	33·18	34·62	15·35	15·17	7·73	6·37	18·34	27·91
Potassium (K)	1·65	2·48	2·61	4·82	4·61	8·24	3·59	5·89	6·09
Sulphuric acid (SO_4)	34·65	12·32	8·78	46·54	32·97	53·62	7·98	41·27	44·58
Chlorine (Cl)	30·06	48·41	50·79	14·17	30·11	6·01	57·51	12·24	7·58
Bicarbonic acid (HCO_3)	0·56	0·93	1·86	5·66	3·29	7·22	2·96	13·10	13·84
Conventional combinations :—									
Calcium sulphate ($CaSO_4$)	49·10	9·12	4·89	45·68	34·30	58·25	11·29	31·00	..
Calcium chloride ($CaCl_2$)	2·77	..	..	..	..	..	17·76	..	..
Magnesium sulphate ($MgSO_4$)	..	..	..	..	10·98	..	..	..	..
Magnesium chloride ($MgCl_2$)		..	..	..	5·93	..	46·54	..	..
Potassium chloride (KCl)	3·13	4·72	4·96	9·23	8·79	12·54	6·86	11·14	11·52
Potassium bicarbonate ($KHCO_3$)	..	..	..	..	..	4·30	..	..	..
Sodium chloride (NaCl)	44·23	76·18	79·71	16·17	35·50	..	13·57	11·36	3·52
Sodium sulphate (Na_2SO_4)	..	8·70	7·89	21·13	..	18·56	..	28·60	65·98
Sodium bicarbonate ($NaHCO_3$)	0·77	1·28	2·55	7·79	4·50	6·35	3·98	17·90	18·98
Per cent. soluble	10·54	9·01	5·80	1·69	1·82	1·16	4·11	0·92	1·47

The following table gives the results of mechanical analyses of samples of soils collected in Egypt :—

Number	Locality	Description	Organic matter	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0·5 mm.	Medium sand, 0·5 to 0·25 mm.	Fine sand, 0·25 to 0·1 mm.	Very fine sand, 0·1 to 0·05 mm.	Silt, 0·05 to 0·005 mm.	Clay, 0·005 to 0·0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7538	Aboukir tract .	Loam, 0 to 6 inches	0·65	0·52	0·40	0·38	18·42	35·66	28·46	16·16
7539	Do. .	Loam, 0 to 12 inches.	0·50	0·02	0·08	0·16	23·34	42·68	21·00	12·52
7544	Do. .	Clay loam, 0 to 12 inches.	0·89	0·14	0·30	0·18	2·32	4·14	35·08	57·44
7545	Do. .	Clay loam, 12 to 24 inches.	0·69	0·00	0·10	0·06	3·86	15·90	30·72	49·30
7546	Do. .	Clay loam, 24 to 36 inches.	1·04	0·00	0·04	0·04	0·92	5·76	51·28	41·64
7540	Do. .	Clay loam, 0 to 6 inches.	0·29	0·46	0·68	0·42	6·26	8·26	31·40	51·08
7541	Do. .	Clay loam, 6 to 12 inches.	0·44	0·20	0·28	0·32	3·52	5·42	37·30	52·48
7542	Do. .	Clay loam, 0 to 6 inches.	0·24	0·30	0·42	0·36	3·68	9·48	28·28	57·02
7543	Do. .	Clay loam, 6 to 12 inches.	0·83	0·20	0·56	0·24	1·76	8·74	25·76	62·62
7555	Kom-el-Akhdar	Clay loam, 0 to 12 inches.	0·45	1·84	5·80	4·20	21·94	15·84	7·48	42·10
7556	Damru . .	Clay, 0 to 12 inches	2·46	0·60	0·88	0·20	0·58	4·98	37·08	55·46

CHAPTER V.

Reclamation Work in India.

The reclamation works in India best known to the writer are those of Dr. Leather and Mr. Barnes and the Daulatpur reclamation station in Sind.

Dr. Leather analysed a large number of salt samples and mapped areas of salt lands in canal areas of the United Provinces. The results are published in a United Provinces Government blue book[1]. The late Mr. J. Hector Barnes[2] reclaimed a plot of salt land near Lyallpur in the Punjab and did a considerable amount of laboratory work in connection with it.

The history of the Daulatpur reclamation station is fully described in Bulletin 64 of the Department of Agriculture, Bombay (1914). This station consisted of 400 acres of light salt land. The reclamation work was not carried out so far as it might have been, but it was conclusively proved that the Egyptian methods were applicable to Sind. The difficulty in carrying out this work to a conclusion was that till the Indus Barrage is completed there is only enough irrigation water for the good land. So having proved the fact that reclamation on standard lines presented no difficulty the Sind Agricultural Department had to switch on to more urgent work.

When the Indus Barrage and the new system of canals is completed, say, within the next 15 years or so, reclamation work will have to receive attention again.

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[1] Leather, J. W. "Investigations on *Usar* Land in the United Provinces."

[2] Barnes and Barkat Ali. "Alkali soils: Some biochemical factors in their reclamation." *Agric. Journ. Ind.*, Vol. XII, p. 368.

Analysis of Daulatpur soils

Salt	Square 64		Square 66		Square 68		Square 3		Square 5	
	Surface	2′ down	Surface	2′ down	Surface	2′ down	Surface	2′ down	Surface	2′ down
Sodium carbonate	...	...	...	...	...	...	...	...	...	0·00526
„ bicarbonate	0·0167	0·02500	0·03750	0·03750	0·03750	0·04170	0·0292	0·0334	0·02500	0·02920
„ sulphate	...	...	...	0·17920	...	...	...	0·0450	...	...
„ chloride	...	0·28380	1·22900	0·91340	0·26350	1·09400	0·0753	0·0548	0·22840	1·09200
Magnesium sulphate	...	0·10270	...	0·08110	0·00600	0·05250	...	0·0595	...	0·07570
„ chloride	0·0342	...	0·09840	...	0·05514	0·09110	0·0385	...	0·06420	0·05130
Potassium sulphate	...	...	...	0·01256	...	...	...	0·0161	...	...
„ chloride	...	0·01075	0·00768	...	0·00461	0·01379	0·0199	...	0·01690	0·01070
Calcium sulphate	0·0175	0·25160	0·05250	0·12920	0·17690	0·11560	0·1196	0·0884	0·00875	0·03400
„ chloride	0·0356	...	0·12350	...	...	...	0·0134	...	0·04830	...
Total soluble alkali	0·1040	0·67385	1·54858	1·35296	0·54365	1·40869	0·2959	0·2972	0·39155	1·29816

Salt	Square 7		Square 24		Square 26		Square 28	
	Surface	2′ down	Surface	2′ down	Surface	2′ down	Surface	2′ down
Sodium carbonate	...	0·00343	...	...	...	...	...	...
„ bicarbonate	0·02500	0·03540	0·02086	0·02920	0·02086	0·02919	0·02919	0·02919
„ sulphate	0·59390	0·11790	...	...	...	...	...	0·20040
„ chloride	1·03500	0·33490	0·29710	0·43990	3·06100	0·92180	0·78200	0·48710
Magnesium sulphate	0·11350	0·12970	...	...	...	...	0·04140	0·09390
„ chloride	...	...	0·14970	0·18400	0·32080	0·12830	0·04853	...
Potassium sulphate	0·00538	0·00359	...	...	...	...	...	0·01436
„ chloride	...	...	0·00614	0·00614	0·01689	0·01353	0·01382	...
Calcium sulphate	0·23120	0·02041	0·35280	0·29750	0·35870	0·03500	0·20400	0·22090
„ chloride	...	...	0·11710	0·05700	0·22890	0·12120	...	...
Total soluble alkali	2·00398	0·64533	0·94370	1·01374	4·00715	1·24902	1·11894	1·04585

CHAPTER VI.

Conclusions.

The following are the opinions of the writer in regard to salt land reclamation work in India :—

1. Methods successfully adopted in Egypt are suitable for North-West India.
2. Washing the salt into the subsoil is the only effective method of dealing with the problem.
3. Surface washing and running the salt-impregnated water off periodically is a wasteful and unsatisfactory method except under very special circumstances.
4. In North-West India owing to the depth of the subsoil water, the drainage problems are simple and this generally renders the whole reclamation problem much easier of solution. The field drains are necessary to form units for levelling but the system of main drains is in the meantime unnecessary. Drains fill from beneath, and they will remain empty so long as the water can get down to the low subsoil level.
5. Careful levelling is essential. The small drains are useful to mark off the plots and to provide earth for the bunds. Water should be taken direct to each plot. It should never be fed from plot to plot, and while washing the plots should be kept full.
6. After washing the physical texture of the soil must be improved by suitable cropping; this is done in practice most easily by feeding cattle on the land on leguminous fodder crops.

Syngamus laryngeus in Cattle and Buffaloes in India.

[*Received for publication on 9th August, 1919.*]

THE only published account of a *Syngamus* parasite occurring in cattle appears to be that by Railliet in the *Comptes Rendus de la Société de Biologie* for 1899, p. 174.

In the records of this laboratory there is evidence that the same or a similar parasite was found in cattle at Muktesar in 1897, but no account of it was published.

In 1916 it was observed independently by one of us (A. W. S.), and again in 1918 (A. L. S.)

This note is based upon the examination of worms obtained from animals, hill bulls and buffaloes, used for the production of rinderpest virus, and also from plains cattle of various ages and of both sexes killed in the slaughter-house at Bareilly.

Nearly two hundred buffaloes, one hundred plains cattle, and nearly five hundred hill bulls have been examined. Parasites were found in about 13 per cent. of the buffaloes and hill bulls, and about 15 per cent. of the plains cattle. The maximum number found in any one animal was 17 in the case of the hill bulls, 24 in the case of the buffaloes, and 16 in the case of plains cattle. As a rule, however, only one or two were found.

With few exceptions, all were found attached to some part of the larynx. They have been found on the inner surface of the arytenoid cartilages, the bezel of the cricoid near its anterior edge, the vocal cords, the lateral ventricles and epiglottis (Fig. 1).

The observation of 1916 is not taken into consideration in the above statement regarding the usual situation of the parasite.

In that case the subject was a hill bull which had been used for some time for the preparation of anti-hæmorrhagic septicæmia serum.

The animal had been coughing frequently and had had a poor appetite for some days when it was noticed that particles of food were expelled from the nostrils during the act of coughing. This had continued for a few days when the animal died unexpectedly during the night.

Apart from extreme debility, which was probably due to the repeated injections and bleedings which the animal had had to undergo as a serum-maker, the general post-mortem yielded negative results.

The mucous membrane of the pharynx was, however, congested, and there were found adhering to it and to the back of the soft palate some ten or twelve pairs of worms. A few were also found attached to the mucous membrane of the larynx. It is probable that the parasites present in the pharynx set up some degree of irritation which was responsible for the symptoms observed during life.

As already mentioned, the parasite has been found in bulls coming from the Kumaun and Garhwal hills, and in buffaloes and cattle from the Bareilly District in the plains. That buffaloes in the plains are actually infected with the parasite independently of any infection they may possibly have contracted at Muktesar, is proved by the fact that a watch was kept at the Branch Laboratory at Bareilly during the cold weather among buffaloes purchased locally, and a number of specimens were found.

That the bulls did not acquire the infection from buffaloes in Muktesar is indicated by the fact that the percentage of infected animals is about the same in both species, and by the fact that bulls coming from the hills are kept in separate kraals from the buffaloes until they are brought into the sheds. As virus producers their life in the sheds is too short to permit of their becoming infected in such numbers.

These points establish the facts that both cattle and buffaloes are hosts of the parasites, and that the infection is about as common in the plains (at least so far as the Bareilly District is concerned) as in the hills.

Age appears to play no part in determining the infection as the parasite has been found in animals of all ages from 1 to 12 years old.

Morphology. The majority of the parasites are bright red in colour, but occasionally one or other or even both of a pair may be quite white. This is no doubt due to their having ceased to suck blood for some reason or other.

Railliet gives the measurements of the worms found in cattle in Annam as follows :—Males from 3 to 3·375 millimetres in length by 360 to 375 microns in thickness ; females 8·75 to 9·8 millimetres in length by 550 to 570 microns in thickness.

The specimens which we have had for examination have given the following range of size :—Males 3 to 5 millimetres in length by 340 to 375 microns in thickness ; females 7 to 20 millimetres in length by 450 to 675 microns in thickness (Fig. 2).

From this it will be seen that many of the worms examined by us were at least twice as large as those examined by Railliet.

Male worm. The male is approximately constant in thickness throughout its length (Fig. 3), but shews a slight abrupt constriction at the line of junction between the body and the caudal bursa (Fig. 4).

In no instance have males and females been found unattached to each other.

The cuticle does not shew any distinct cross striation in the fresh condition, but it can be made out obscurely in preserved specimens, and it is distinctly visible in specimens that are partially dry.

The anterior end is squarely truncated and shows the circular mouth.

At a distance of about 0·75 mm. from the anterior end the cuticle shews a small blunt tubercle on each side of the body (Fig. 5).

The caudal pouch is somewhat poorly developed as regards its size (Figs. 3 & 4).

Alimentary tract. The mouth is circular and is surrounded by a thin transparent membranous lip. From the examination of longitudinal sections it appears that this lip is composed of two layers between which there is a space which forms a closed canal round the orifice (Fig. 6. A). A similar canal encircles the parasite just posterior to this.

The buccal capsule is almost hemispherical in shape and is composed of thick chitinous material (Fig. 6. B).

At the bottom of the capsule, round the opening of the œsophagus, there are eight small elliptical holes (Fig. 6. C). Immediately external to these there is a ring of eight chitinous points projecting forwards into the mouth cavity (Fig. 6. D). From the base of each of these there arises a thick rib which runs up on the inner surface of the capsule.

It is a somewhat peculiar fact that only six of these ribs reach the margin of the capsule. One pair which are opposite to each other fade out when about two-thirds of the distance has been traversed (Figs. 7 & 8). In this respect the parasite is possibly different from that referred to by Railliet who describes the whole of the ribs as reaching the margin. The margin of the capsule is thus divided into six segments only, of which two are twice as large as the remainder. Examination of the capsule under a high magnification shews that throughout its extent it is beset with minute perforations set closely together (Figs. 6 & 9).

The œsophagus which has the usual club-like shape is particularly well developed. The intestine runs a practically straight course to the hinder end of the body.

The anterior part of the intestine is expanded in such a manner as to almost merit being termed a stomach. In fresh preparations this "stomach" is shaped like a peg top, the bulbous end being the anterior one (Fig. 10). In fixed specimens it is generally telescoped.

The minute anatomy of the intestine is the same throughout its length. Outwardly there is a layer of large cells whose margins are difficult to make out. These cells not infrequently have a frothy appearance as if crowded with fat droplets. On the inner face of these there is a thin layer of homogeneous material which stains intensely with eosin. The inner surface of this layer is covered with short rod-like structures set at right angles to it and packed closely together (Fig. 11).

When seen from the surface this layer has a mosaic-like appearance. Posteriorly the intestine opens into a funnel-shaped cloaca (Fig. 12).

Genital system. The striking fact in connection with the genital system of the male parasite is the complete absence of any spicules. The entire system appears to be represented by a single tube which is closed anteriorly and opens posteriorly into the cloaca. This tube is about three-quarters the length of the whole worm, but is invariably coiled so as to occupy a position in the hinder half of the parasite only (Figs. 3, 4).

Structurally the tube comprises two distinct parts which are approximately equal in length. The anterior half of the tube is the germinal portion in which the spermatozoa are developed (Fig. 13. A). Here the tube is packed with small rounded cells with compact nuclei. These cells do not appear to be provided with any locomotor apparatus. The hinder portion of the tube shews a distinct lumen bounded by large cells. In paraffin sections the spermatic fluid can not infrequently be found in the lumen of this portion of the tube (Fig. 13. B).

The tube enters the cloaca dorsally to the intestine.* The cloaca has a comparatively narrow outlet but no accurate measurements could be made as some degree of distortion takes place when sections are cut, no matter what method is adopted, and the orifice of the cloaca cannot be seen distinctly except in sections.

The caudal bursa (Figs. 3, 4 & 14), which may be considered as part of the genital apparatus, is peculiar in many respects. It is smaller than is usually found in the parasitic round worms, but is very much thicker and is in fact quite fleshy. Its smallness is, however, compensated for as will be seen later. Its small size, thickness, and the closeness with which it adheres to the female make it difficult to study the pouch in detail. A complete idea of the details of the pouch can only be arrived at as the result of the examination of a number of specimens prepared in different ways, sections cut in paraffin, by freezing and teased preparations.

The pouch may be described as more or less saddle-shaped, the panels of the saddle passing over the sides of the female. The lateral lobes of the pouch are connected anteriorly by a flap which is thicker than any other part. This anterior part is recurved, this serving to anchor it firmly to the anterior margin of the flattened boss on the body of the female in which the vulva opens (Fig. 15. A).

Posteriorly the lateral lobes of the bursa are directly connected by a moderately thin flap. This is to some extent recurved in fresh specimens but not to so marked an extent as the anterior lobe (Fig. 15. B).

This arrangement alone would account for a considerable amount of difficulty in detaching the parasites from each other, but the union

* It is assumed that the ventral surface of the male is directed towards the anterior end of the female.

is rendered far more intimate by the fact that the whole of the inner surface of the pouch, with the possible exception of one small area, is closely beset with small crypts (Fig. 16) into each of which is fitted a small pointed projection developed from a special layer on the surface of the female over the whole area included within the grasp of the pouch (Fig. 17).

Sections of the male worm shew that throughout its extent the pouch is spongy in structure. It comprises an inner and an outer dense layer and between these a loose-textured connective tissue, the main strands of which pass straight from one dense layer to the other (Figs. 12, 17 & 18).

The supporting rays of the pouch are poorly developed and difficult to see in detail in intact parasites (Fig. 3).

The best pictures of them have been obtained in serial sections cut in paraffin. From these it is seen that there are two main trunks. The anterior one gives rise to three broad rays with rounded ends which lie in close contact with each other (Fig. 18). From the posterior trunk two rays of a similar nature take origin.

Other organs. In the anterior part of the body there are two large blind pouches which appear to open by a small orifice common to both through the cuticle on the posterior surface of the body at a point opposite the junction of the anterior and middle thirds of the œsophagus (Fig.19).

These pouches become wider as they pass backwards and terminate about the middle point of the body. Projecting from the blind end of each there is a little appendix-like prolongation. The nature and function of these has not been determined. Possibly they are the homologues of the cervical glands described by Looss in *Anchylostoma duodenale.*

In the body cavity, and apparently unattached in any way, there are invariably four rounded bodies (Figs. 3 & 4), measuring 100 to 120 microns in diameter, which are largely composed of closely felted filaments each of which shews a close succession of rounded thickenings, thus producing an appearance resembling a string of beads.

In sections of these bodies two distinct zones can be made out. The outer zone is composed of the filaments described, and a central area which stains more intensely, is finely granular, and in which a few nuclei can be detected. The nature and function of these is also unknown.

Female worm. The female worm of which the measurements have already been given, attains its maximum thickness in the neighbourhood of the vulva. It tapers slightly towards the head and tapers continuously towards the tail where it terminates in a subacute point.

What has been said regarding the presence of striations on the cuticle of the male holds good for the female.

The mouth and alimentary tract of the female are, except in the matter of size, the counterpart of the corresponding parts of the male.

The anus in the female is sub-terminal, at a distance of about 300 microns from the tip of the tail, and takes the form of a transverse slit.

If the piece of cuticle containing the vulva be dissected away from the rest of the parasite and spread out flat, a more or less circular area bounded by a distinct line can be seen under a low magnification. This has a slightly granular appearance and is the area covered by the bursa of the male (Fig. 21).

In serial longitudinal sections it is found that this line circumscribes a flattened boss which is slightly undercut to give anchorage to the recurved flaps of the caudal pouch of the male. This undercutting is most marked in worms that have been sectioned while still attached to each other. If the worms be separated before fixing, the boss is scarcely salient at all.

The vulva takes the form of a transverse opening and is not furnished with any protective appendage or prominent lips. It opens somewhat posteriorly to the central point of the boss. As already mentioned, the boss is covered with a specialized layer the surface of which shews immense numbers of little pointed processes for insertion into the crypts on the under-surface of the bursa of the male (Figs. 17 & 22). It appears to be probable that this specialized layer is in reality in the nature of a cement substance which is drawn up into the crypts of the pouch by suction. It is difficult to suppose that actual outgrowths of the cuticle could be fitted so accurately into so many minute crypts of varying size. It is probable that there is one area of cuticle, extending backwards from the vulva, which is not in intimate union with the under-surface of the caudal pouch.

Sections have been examined in which eggs had reached the vagina and even the vulva, and were on the point of being extruded. In view of the facts that the vagina is directed backwards and that the vulva opens posteriorly to the centre of the area covered by the pouch, it seems to be reasonable to suppose that the eggs are passed out under the posterior flap of the pouch. That there must be some channel of this sort is indicated by the fact that there must be some means of escape for eggs and for the waste material passing from the alimentary canal of the male.

The less complete anchorage of the posterior lobe of the pouch also suggests that this may be the case.

It would appear to be a very wasteful procedure on the part of Nature if, as has been suggested, the eggs can only escape as a result of rupture or disintegration of the body of the female. This would be tantamount to the death of the parent worm. A very large proportion of the eggs liberated would in all probability not be viable.

That the view put forward is correct is borne out by the fact that eggs have been observed on a number of occasions in the act of escaping

from beneath the caudal pouch of the male. Living worms were obtained and placed in 0·4 per cent. salt solution. Under a dissecting microscope the eggs were observed to be ejected with some force from under the posterior flap of the caudal pouch, in some cases at intervals of a few seconds and in others at very long intervals.

Genital organs of the female. The ovaries and uteri are twisted round themselves and round each other in so complicated a manner that it has been found impossible to disentangle both branches of the system, for the purpose of measurement, without damage. In many instances it has been found possible to ascertain the length of one branch by sacrificing the other. It has been found that the length varies from two to two and a half times the total length of the worm.

From the examination of serial longitudinal sections it appears that the vagina, which is very short (Fig. 21), opens into a funnel-shaped vulva which is compressed dorsi-ventrally. In many paraffin sections the minute cells described as being present in the duct portion of the male genital tube could be found crowded into the funnel-like opening and passing down into the uteri (Figs. 23 & 24).

From the vagina, which is about 150 microns in length and which is provided with very thick walls, two uteri take origin. These are thin-walled tubes which vary greatly in diameter, depending upon the number of eggs contained in them. They measure about 5 millimetres in length in a fully grown parasite. Each branch of the uterus is continued as a long slender ovary measuring 40 to 50 millimetres in length. The ovaries terminate blindly. The blind pouches, described as being present in the anterior part of the male, and the four ball-like structures are present in the female worms, and are proportionately larger.

Eggs. In the distal portions of the ovaries the first evidence of egg formation is the appearance of segmentation in the ovarial contents. In sections stained with hæmatein and eosin the segments are found to be crowded with granules staining intensely with the hæmatein. Further down the tubes, where the eggs have assumed the oval shape, these granules are found disposed at the surface and closely touching each other. In the next stage of development the granules have entirely disappeared and the shells of the eggs have made their appearance (Fig. 25). It appears to be probable that the shells are made from these granules.

The whole process very closely resembles that observed in the stages of development of the oocyst from the macrogamete of Coccidium.

The most mature eggs found in the uteri are in the morula stage comprising eight cells, but eggs were found in the mucus on the surface of the membrane of the larynx in which only two cells could be seen (Fig. 26).

The mature eggs measure about 80 microns in length by 40 in width No evidence of an operculum can be found.

Pathogenic effects. With the exception of the special case cited above no disturbance of health has been noted as being caused by the parasite.

Figures 27 and 28 shew respectively longitudinal and transverse sections of the mouth parts of parasites still attached to the mucous membrane.

In Figure 26 it is seen that a "button" of the membrane is drawn into the mouth, and no doubt the chitinous points or lancets set round the opening of the œsophagus puncture the membrane and thus enable the parasite to withdraw blood.

Technique. It has not been found possible to obtain uniformly satisfactory results by any of the methods of preparing sections that have been described, but good results have been obtained at different times with all of them.

It was found to be essential for the penetration of the paraffin to make an opening in the integument as it offered a great resistance. This was generally effected by cutting off a portion of the worm that was not required for examination. It was frequently found to be of great assistance in cutting sections of the worms to adopt the plan described by Looss of painting the surface of the paraffin block with a thin solution of celloidin between each cut.

The chitinous parts of the mouth presented great difficulty when cutting specimens embedded in paraffin, as they shewed a great tendency to crack.

To overcome the difficulty of small parts of the sections becoming detached from the slides while the processes of paraffin extraction and staining were being carried out, the plan was on some occasions adopted of staining the specimens without removing the paraffin. It was found that this could be done successfully *provided the paraffin wax was not actually melted when the sections were placed upon the surface of warm water* prior to placing them upon the slides. The processes of staining and dehydration were carried out in the usual way and the xylol used for clearing simultaneously removed the paraffin and left the specimens ready for mounting in balsam. The painting of the surface of the block with celloidin did not interfere with this method as the celloidin was removed by the alcohol used for dehydration.

On a large number of occasions, sections, quite satisfactory for some purposes, were cut with the freezing microtome. These sections were washed off the razor either singly or two or three at a time by ejecting a gentle stream of water from a pipette on to the surface of the blade and draining it with the sections either on to a slide or into a watch glass.

Fig. 1. A larynx laid open by cutting through the bezel of the cricoid. Shews a group of worms attached to the ary-epiglottic fold on each side.

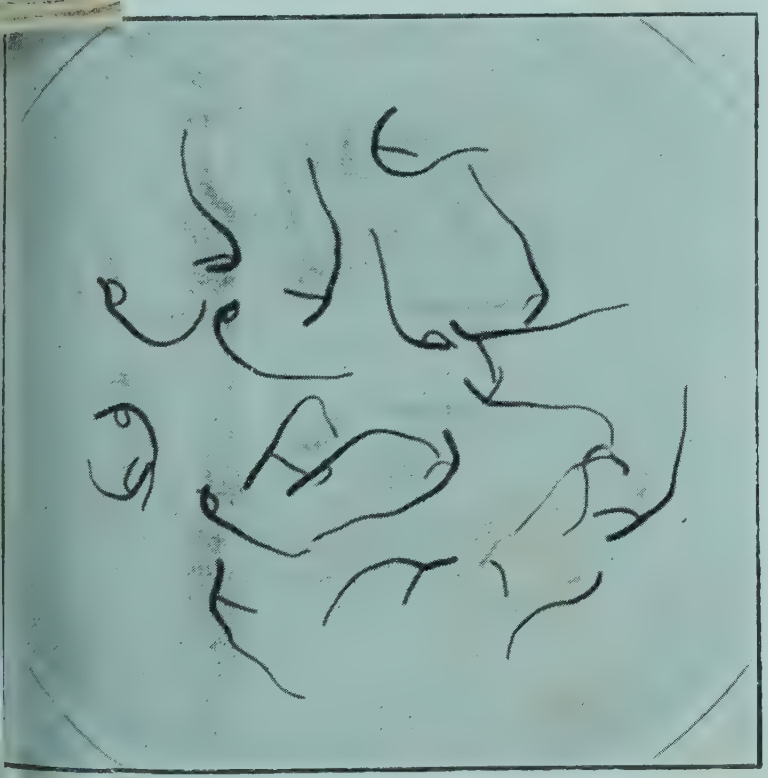


Fig. 2. A number of parasites photographed exactly natural size. In the right hand lower corner, there is a red female with a white male attached to it (the male is scarcely visible against the white background) and close to this is a red male attached to a white female.

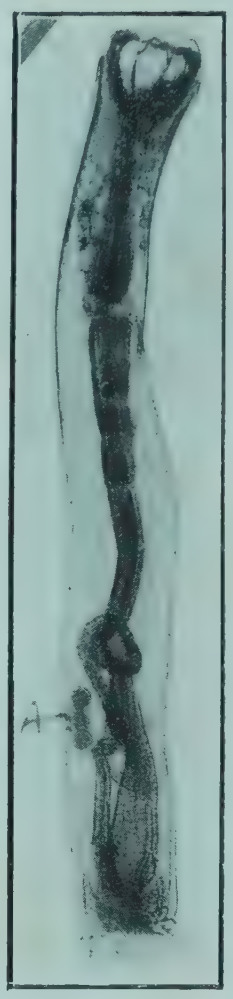
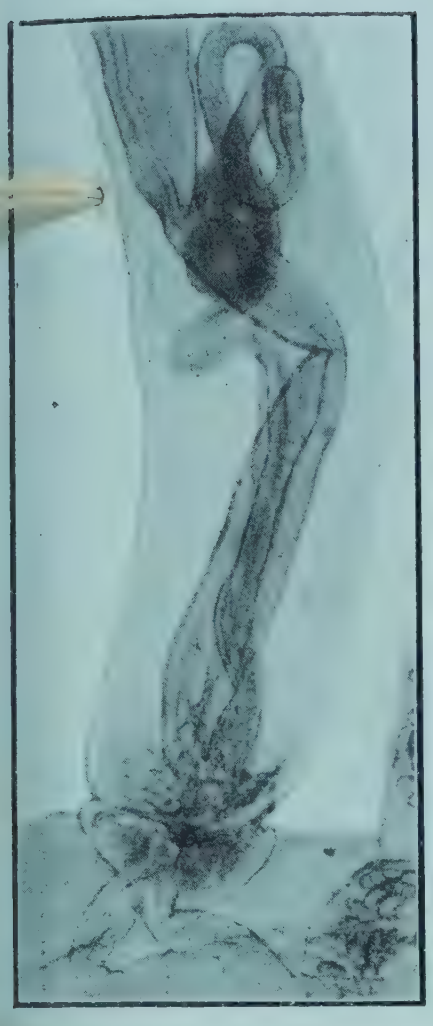


Fig. 3 (× 20). Detached male parasite shewing the straight intestine, single blind seminal tube, the small size of the caudal bursa (the rays of which can be seen very indistinctly). Three of the rounded bodies at A.



4. The junction of the male and female slight constriction at the junction of the caudal bursa with the body, the single blind seminal tube, the small caudal bursa, two of the rounded bodies.

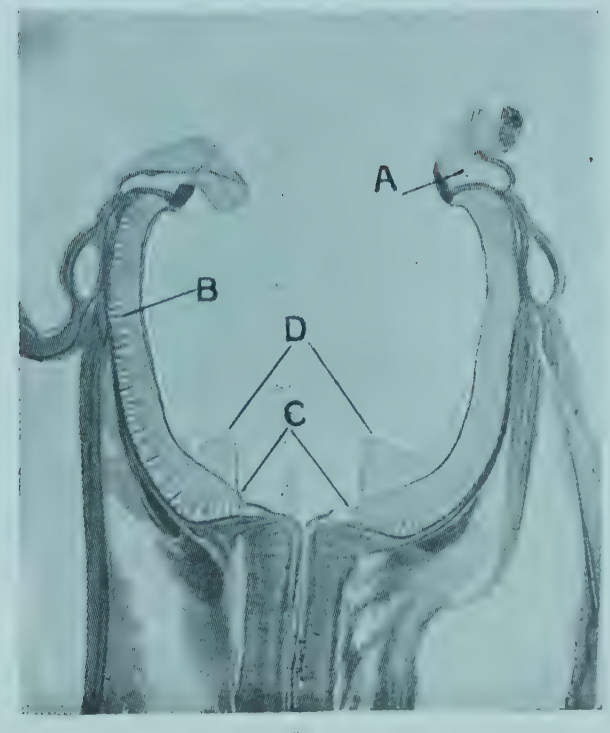


Fig. 6 (×150). Longitudinal section of the mouth shewing
(A) the membranous lip containing the canal,
(B) the thick chitinous capsule,
(C) elliptical holes in longitudinal section,
(D) chitinous points.

Note the striated appearance of the chitin. This is due to perforations. (See also Fig. 9.)

g. 5. Anterior end of the male shewing two blunt tubercles on either side of the body.

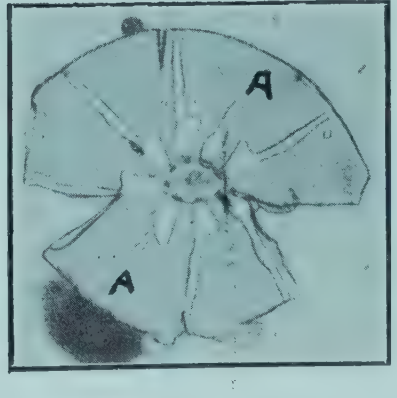


Fig. 7 (×40). A chitinous buccal capsule dissected out and flattened shewing—AA the short ribs, also the chitinous points and the ring of elliptical holes shewn in Fig. 6.

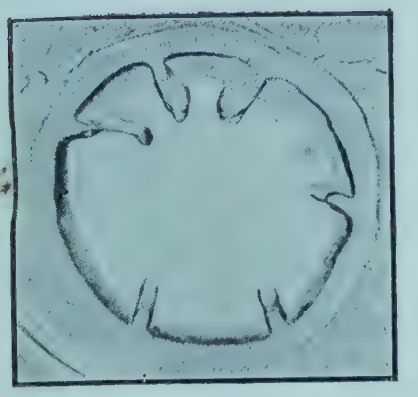


Fig. 8 (×75). Transverse (almost) section of buccal cavity cut above the point where one pair of ribs disappears leaving six only.

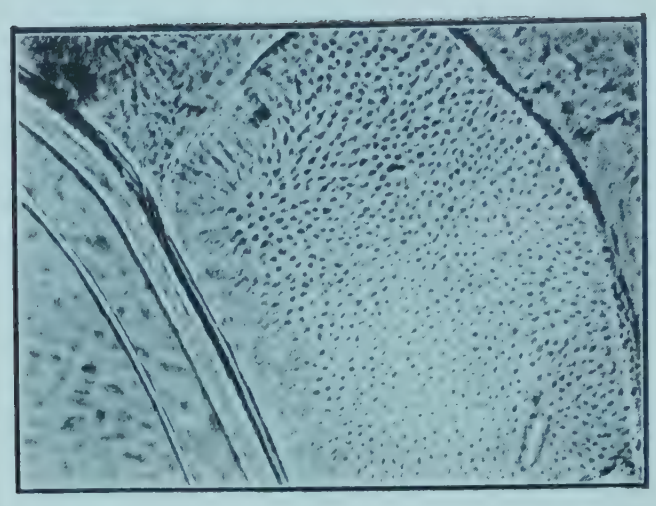


Fig. 9 (×150). A portion of the buccal capsule seen from the surface. On the left is the membranous lip. The perforations in the chitin are clearly shewn.

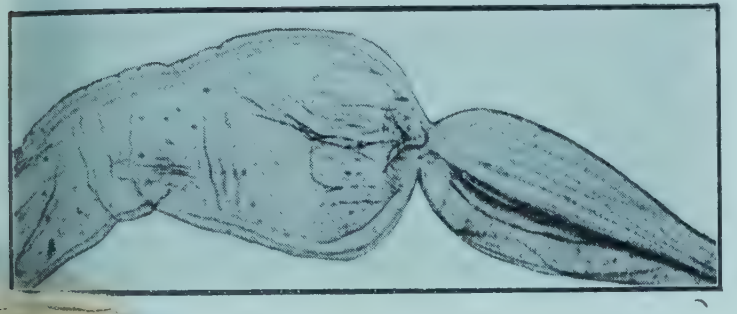


Fig. 10 (×40). The hinder portion of the œsophagus and the stomach.

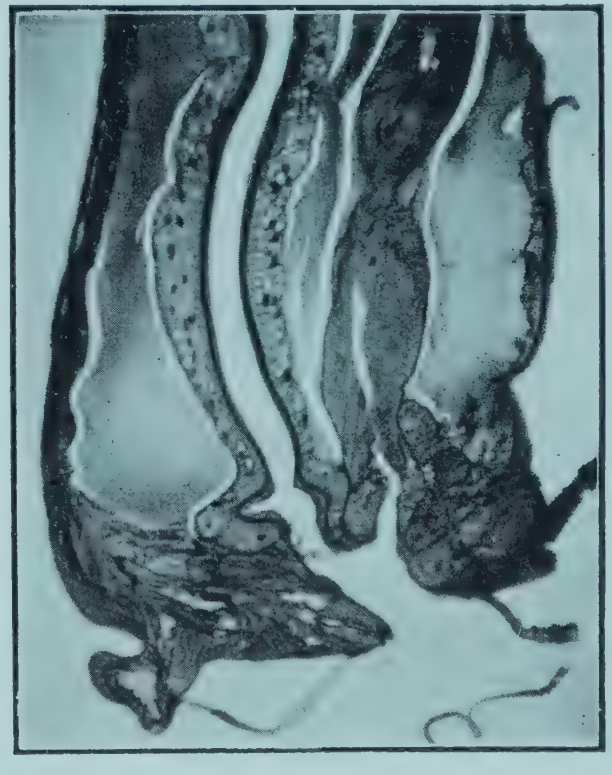


Fig. 12 (×150). Shewing cloaca with the intestine entering it on the left (*i.e.*, ventrally in the living specimen) and the seminal tube on the right (*i.e.*, dorsally). The terms ventral and dorsal are used assuming that the ventral surface of the male is turned towards the anterior extremity of the female.

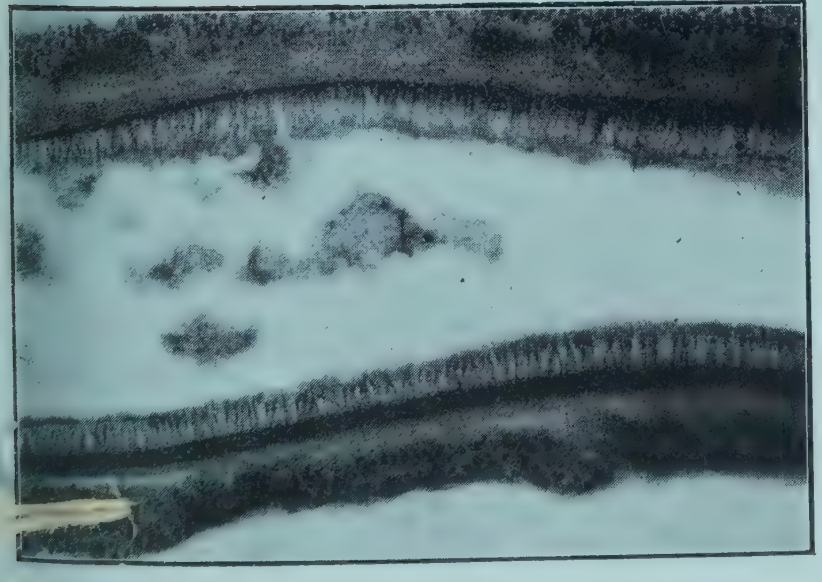


Fig. 11 (×500). A portion of the intestine shewing the outer cellular layer, the intermediate homogeneous layer, and the inner layer of rods.

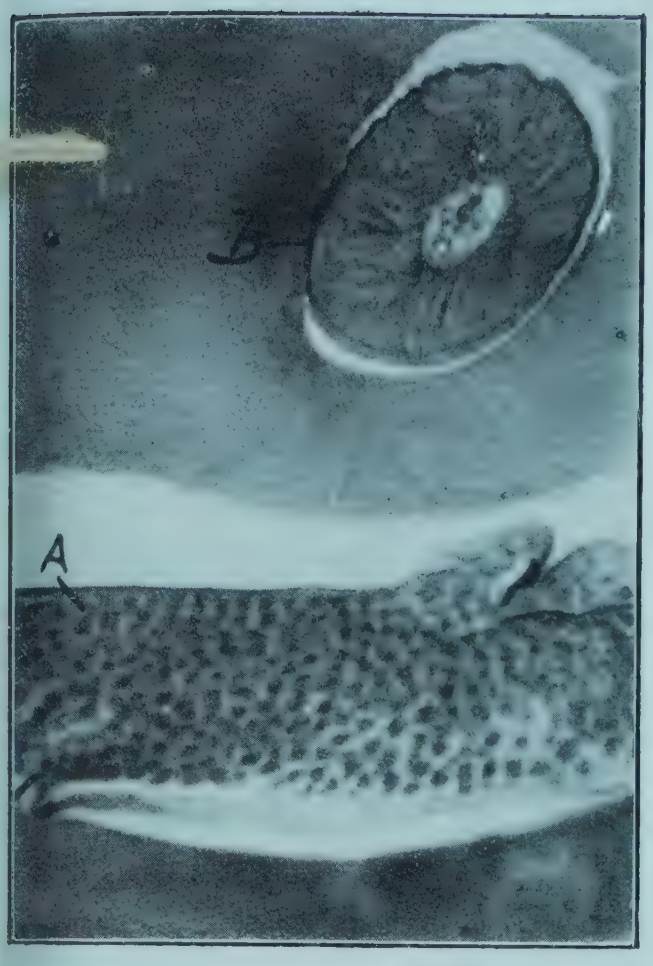


Fig. 13 (× 460). Section of two parts of the seminal tube of the male.

Fig. 14 (× 40). Antero-posterior view of the caudal pouch of a detached male (the right half is slightly damaged) shewing the thick fleshy nature and its small size.

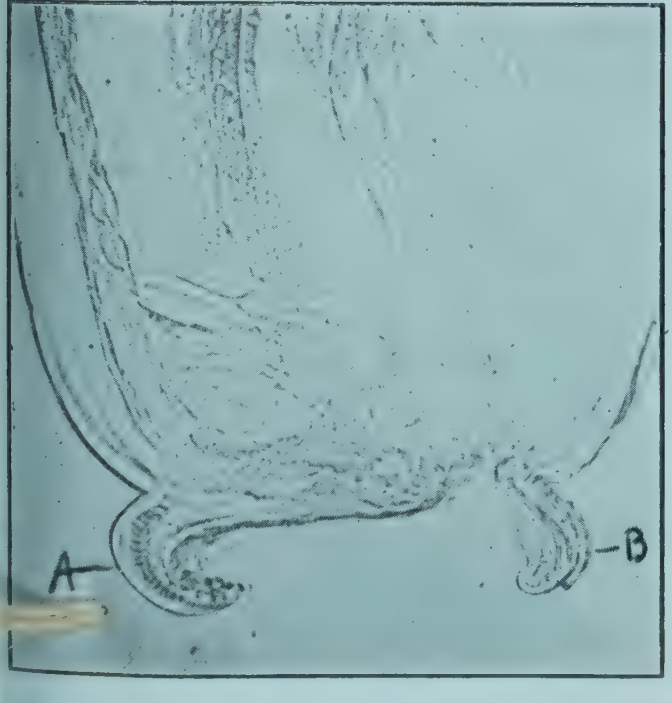


Fig. 15 (× 150). Frozen longitudinal section unstained. Shewing at A the recurved anterior flap of the pouch, and at B the less curved posterior flap.

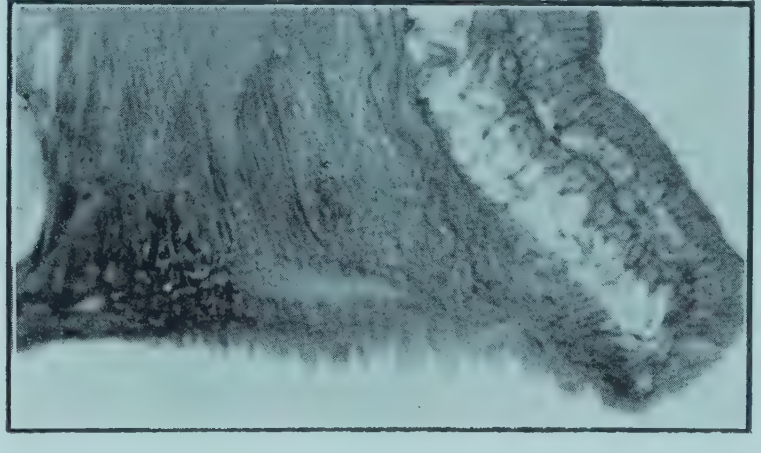


Fig. 16 (× 460). Longitudinal section of posterior extremity of male shewing crypts on the inner surface of the pouch.

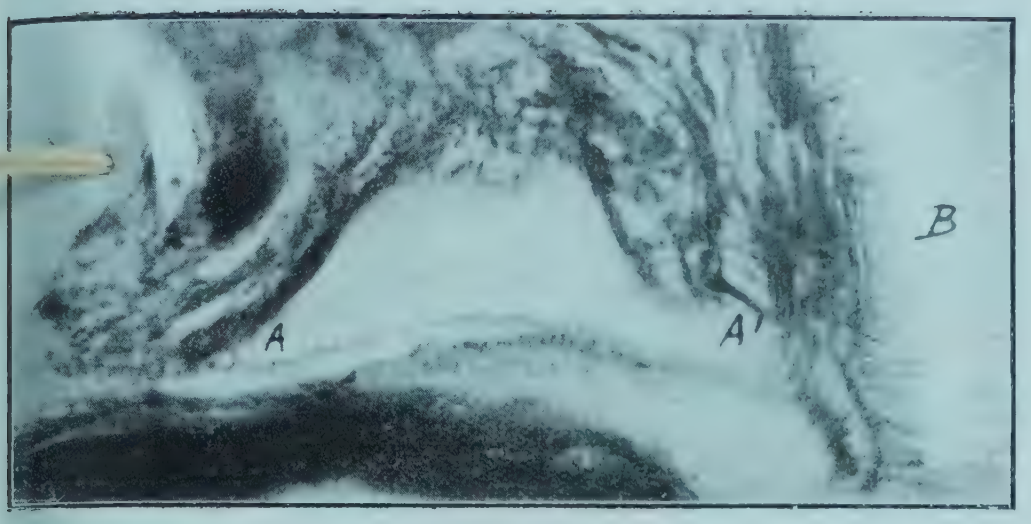


Fig. 17 (× 460). Section through the junction of a male and female. Line of junction at A—A′ shewing the pointed projections fitted into the crypts on the inner surface of the pouch. B, the spongy portion of the pouch.

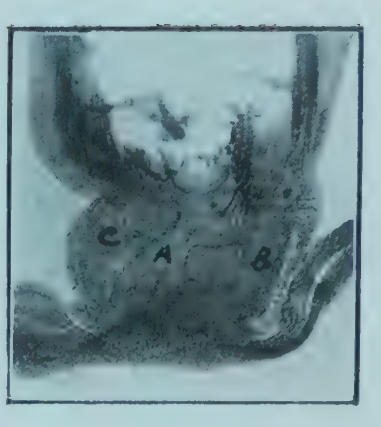


Fig. 18. Longitudinal section through one of the lateral lobes of the pouch shewing the anterior trunk giving rise to three rays, A.
B. Posterior ray.
C. Spongy pouch.

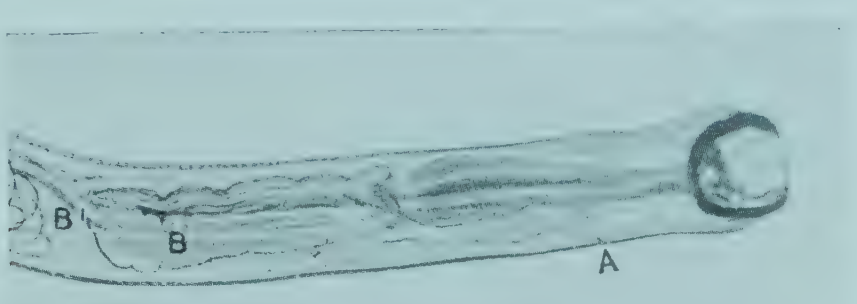


Fig. 19 (× 27). Shewing the two blind pouches extending from the common orifice at A to B & B′. One is partly concealed by the other.

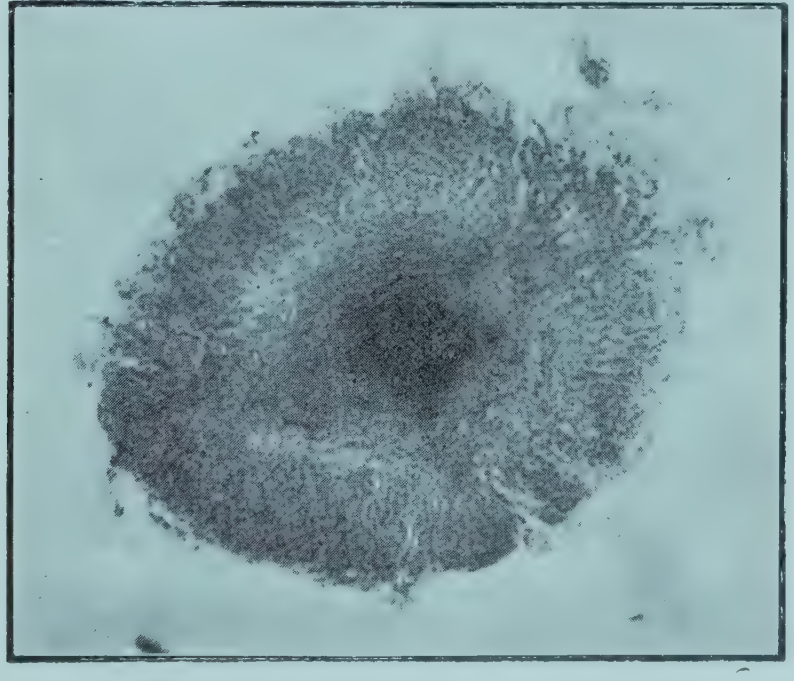


Fig. 20 (× 460). Section of a "rounded" body shewing the other filamentous zone and the inner granular area in which there appear to be some nuclei.

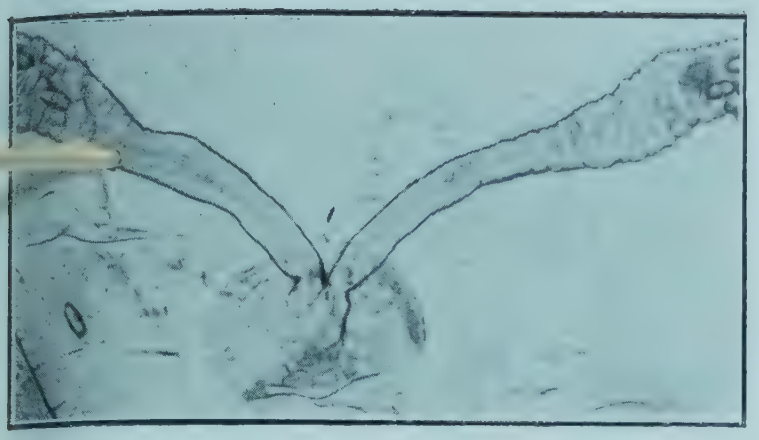


Fig. 21 (× 40). Portion of cuticle of female containing the vulva and shewing the area covered by the pouch of the male, the short vagina, and the anterior portions of the uterine tubes.

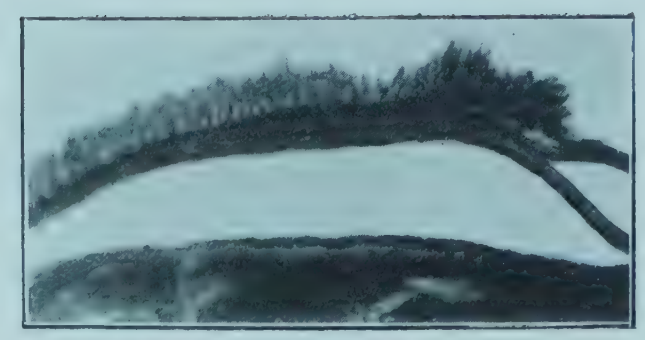


Fig. 22 (× 460). Specialized layer of "boss" of female shewing the projections which fit into the crypts of the pouch of the male.

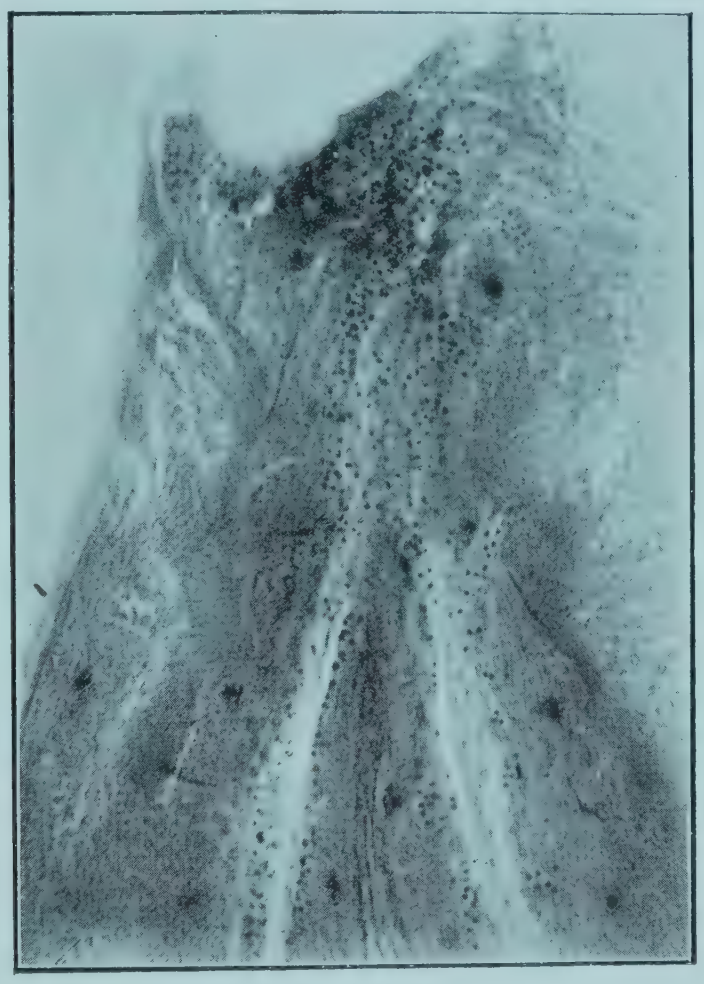


Fig. 23 (× 460). Longitudinal section (dorsi-ventral) of the vulva, short vagina and uterine tubes containing the small cells described in connection with the genital tube of the male.

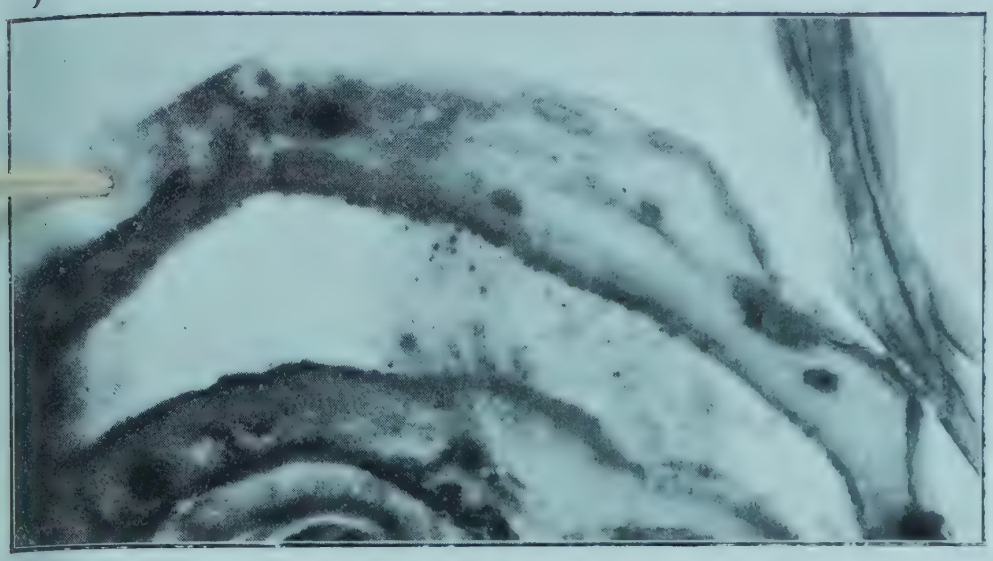


Fig. 24 (×460). Oblique section of a portion of the uterus shewing the small cells described in connection with the germinal tube of the male.

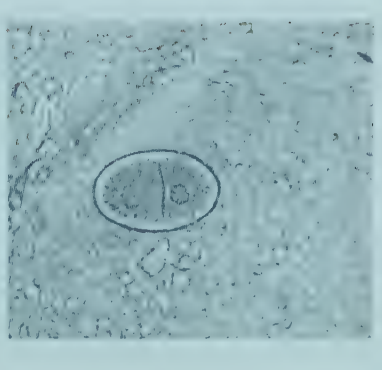


Fig. 26 (×150). An egg in the mucus from the larynx.

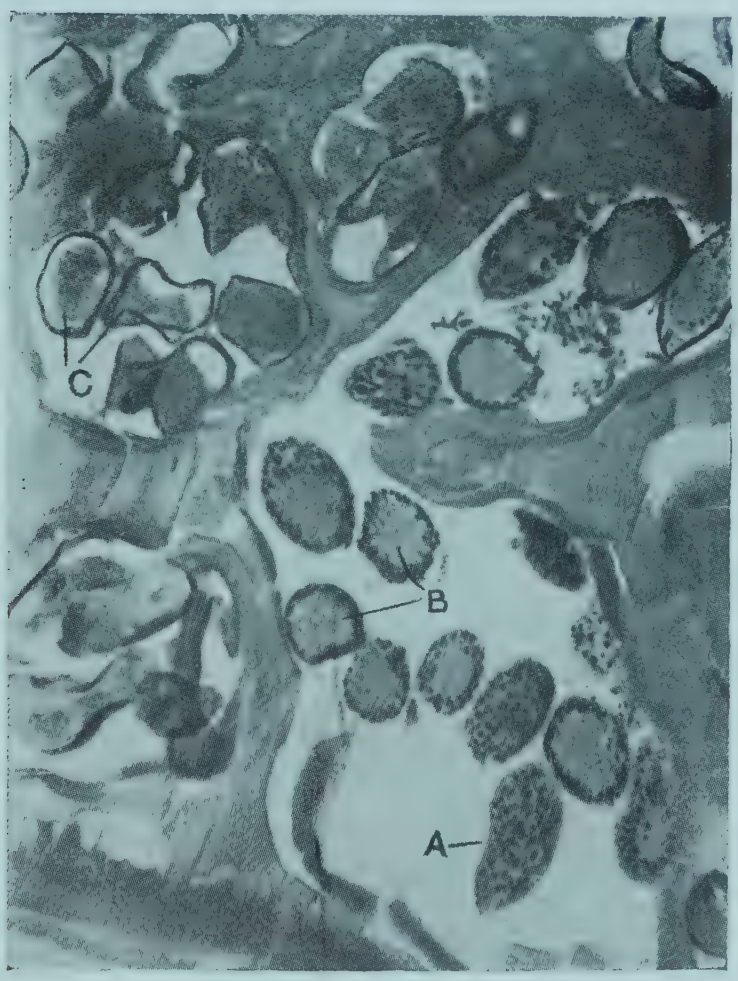


Fig. 25 (×220). Paraffin section through a female shewing eggs in three stages of development.

A. Eggs crowded with granules.

B. Granules disposed at the margin.

C. Granules disappeared and shell formed (these are deformed by the process of embedding, etc.).

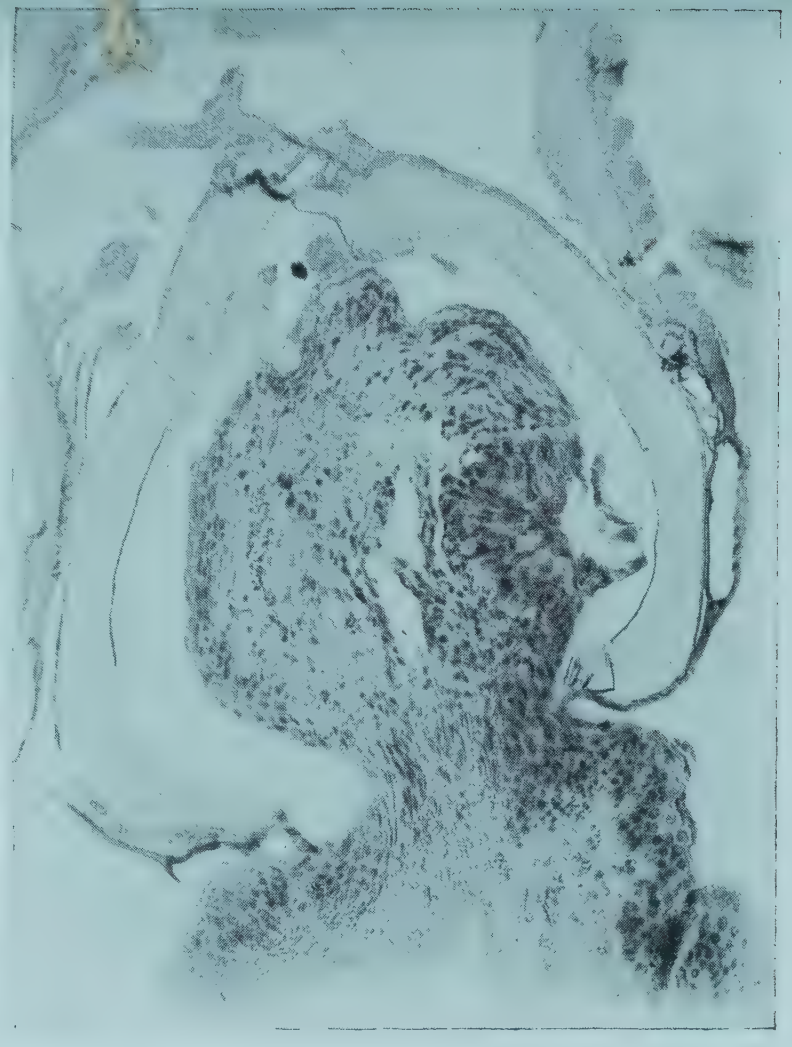


Fig. 27 (×150). Longitudinal section of the mouth of a worm still attached to the mucous membrane, shewing the "bottom" of membrane drawn into the mouth. (In this and the succeeding figure the soft tissues have shrunk somewhat.)

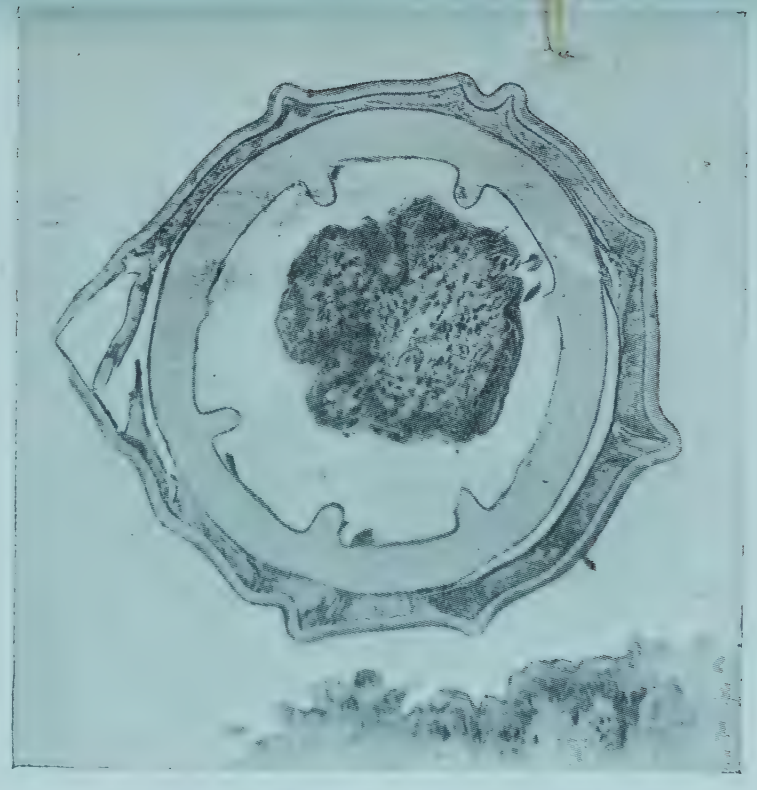


Fig. 28 (×150). Transverse section of the mouth of a parasite still attached to the mucous membrane.

The Orange:
A Trial of Stocks at Peshawar.

(Received for publication on 23rd August, 1919.)

I. Introduction.

In India, an orange tree, which is properly treated, may be depended on to bear a paying crop at the age of six years, and to yield 300 fruits a year for a period of 15 to 20 years after coming to maturity. After visiting many nurseries and gardens throughout India, the writer estimates that nurserymen sell 400,000 orange plants a year—they have probably distributed 8,000,000 plants at the good sum of Rs. 20,00,000 in the past 20 years. If the trees had been set out at 18 feet apart, on simple calculation, India's groves should now comprise no less than 5,000,000 bearing trees on 60,000 acres. And as the average price of oranges is not less than Rs. 2 per hundred, it might be expected that India's orange crop would be worth Rs. 3,00,00,000 a year.

Unfortunately this is very far from the actual state of affairs. A considerable proportion of the budded trees have declined and died without bearing any crop at all : very few of the trees have yielded 300 oranges even for a year or two : not many of the trees have flourished for 20 years. The area occupied by groves is far short of 60,000 acres : the crop is worth but a small part of the grand sum of Rs. 3,00,00,000.

Nevertheless, some vigorous, bountiful trees that have borne an average crop of 300 fruits for many years and, more rarely, profitable highly fruitful groves are occasionally to be seen in various parts of India. These indicate that the orange can be grown very well in the country. Why then are India's groves so unfruitful compared with similar groves in Europe, America or Australia ? What has caused the death of so many of the trees that have been planted ?

In India oranges are set out with care on good land and, generally, the groves are protected from drought. The orange is one of the easiest fruit trees to grow—requiring far less pruning, thinning or spraying than peaches and plums—and as a matter of fact the Malta and the Sangtara orange trees receive more care than several other kinds of fruit trees which reach greater perfection from an Indian gardener's hand. Unsuitable soil, unfavourable climatic conditions cannot be the

factors that cause the comparative failure of the orange in India. The orange flourishes on a great variety of soils over the sub-tropical world, and India has plenty of good fruit land and a considerable range of climate. There must be other circumstances which cause the orange groves of India to fail.

Investigations carried out in many gardens and nurseries throughout India, in the years 1905-11, inclined the writer to believe that this failure has been caused by mistakes in the preparation of the plants in the nurseries. In those parts of India that were visited, it was found that nurserymen employed several kinds of stocks for the Malta and the Sangtara, and as the nurserymen were not fruit-growers, they had no assured knowledge of the effects of the stocks they used on the development of trees in the groves. Indeed, the opinions of nurserymen on the merits of stocks were everywhere contradictory and often palpably unreliable : each appeared to use the stock he could most cheaply and conveniently obtain, or which quickly raised nursery plants fit to sell.

In some other matters the failure of the trees was undoubtedly caused by unfavourable conditions that prevailed in the nurseries. The young plants were overcrowded ; they struggled for existence with old nursery plants and frequently with tough root-weeds. The areas were so small and congested that suitable rotations could not be followed. In the preparation of the plants careless work was also observed. The orange buds were inserted too high in the stocks. Very often old stocks were used on which buds had failed in several previous years.

In short, the nursery plants were found to be badly grown and unreliable. They were altogether inferior to the plants which nurserymen sell in Europe, America or Australia. No fruit-grower in those countries would set out the poor trees which Indian nurserymen customarily distribute.

These are some circumstances that appeared to the writer to account for the failure of orange groves in India. But despite them all, it yet seemed that the proportion of trees which reach mature age and fruitfulness should be far better than it was found to be.

Outstanding clear above all other probable causes of failure were the facts that several distinct kinds of stocks were used : that great difference of opinion existed amongst growers regarding the merits of the various stocks : that all the stocks could hardly be equally suitable to both the Sangtara and the Malta, and that some of the stocks employed might be unsuitable to either the Malta or the Sangtara.

Accordingly, when orchards at the Peshawar Agricultural Station were being laid out in 1911, the opportunity was taken to include a test of the orange stocks which are commonly used for the Malta and the Sangtara in North-West India.

Budded plants were obtained from a reliable Indian source, good clean cultivation was practised, and irrigation was used with caution. No calamity befell the trees during the trial.

The results shown with the Malta and the Sangtara will be dealt with separately.

II. Climate of the Peshawar Valley.

The climate of the Peshawar valley is described in the District Gazetteer as follows :—

Four seasons are recognized at Peshawar : Spring in February, March and April. During the earlier part of this period there are occasional light hail-storms and frequent thunderstorms, and usually rain falls to the extent of three or four inches. Normals of temperature derived from the data of 33 years are as follows :—

Month	Normal maximum temperature	Normal minimum temperature	Normal mean temperature
February	65·7	42·5	54·1
March	75·0	51·7	63·3
April	85·5	60·3	72·9

Summer in May, June and July. Rain rarely falls during this season though thunderstorms sometimes continue well into May which is the hottest of the year. It is frequently hazy, and dust-storms occur in June and July. Normals of temperature are as follows :—

Month	Normal maximum temperature	Normal minimum temperature	Normal mean temperature
May	98·1	69·9	54·0
June	105·9	77·3	91·6
July	102·7	79·2	90·9

Autumn in August, September and October. The season is ushered in by the hot weather rains which do not, however, always reach the valley. October is usually dry. They break over the district in four or five violent storms at intervals of a few days, and two or three inches of rain fall on each occasion. During the first part of this season the sky is more or less uniformly overcast with clouds and the air is steamy and oppressive. Normals of temperature are as follows :—

Month	Normal maximum temperature	Normal minimum temperature	Normal mean temperature
August	99·2	78·0	88·6
September	95·6	70·5	83·1
October	88·2	57·9	73·1

Winter in November, December and January. During this season the weather is variable. The sky is at first hazy, then cloudy, with sometimes slight rain towards the end of December. There is a remarkable absence of wind generally and the air is still and stagnant. The first touch of frost is expected towards the end of November. Normals of temperature are as follows :—

Month	Normal maximum temperature	Normal minimum temperature	Normal mean temperature
November	77·3	46·1	61·7
December	69·0	39·2	53·1
January	63·0	39·6	51·3

The average annual rainfall in the Peshawar valley is 14 inches only. But the experimental groves were irrigated, and never suffered from a deficiency of soil moisture.

III. The Stocks Used.

The trial comprised the following :—

Fifty plants on *Citrus Limonum*, Osbeck, var. This is the "rough lemon" of California and Florida, the "khatti" of the Punjab and North-West Frontier Province, the "kharna" of the United Provinces.

Fifty plants on *Citrus Aurantium*, Linn. This is the " sour " orange of California and Florida, the " khatta " of North-West India, the " narang " of the North-West Frontier Province. It is sometimes called the Seville or marmalade orange.

Fifty plants on *Citrus Limonum*, var. " sweet lime " or " sharbete " or " mitha ". The writer has not seen any accurate botanical description of the " sweet lime ". The fruit is insipid-sweet and is liked by Indians. But it does not appear to be cultivated in Europe, America or Australia.

Fifty plants on *Citrus Medica*, Linn. This is a large coarse citron which is called the " galgal " in North-West India.

IV. The Malta (*Citrus Chinensis*) Grove.

Soil. The following is a report by the Imperial Agricultural Chemist at Pusa on two samples of soils from the Malta grove :—

	0"-1'	1"-3'
Laboratory No.	33-1919	34-1919
	%	%
Moisture (hygroscopic)	0·93	1·02
Combined moisture and organic matter and undetermined	1·38	1·28
Sand and insoluble matters	65·26	64·29
Iron (Fe_2O_3)	4·92	4·78
Alumina (Al_2O_3)	9·61	9·45
Oxide of manganese (Mn_3O_4)	0·02	0·09
Lime (CaO)	9·04	9·92
Magnesia (MgO)	0·68	0·74
Potash (K_2O)	0·94	0·89
Soda (Na_2O)	0·37	0·29
Phosphoric acid (P_2O_5)	0·16	0·14
Carbonic acid (CO_2)	7·58	8·10
Sulphuric acid (SO_3)	0·04	0·03
	100·00	100·00
Available potash (K_2O)	0·017	0·007
„ phosphoric acid (P_2O_5)	0·0038	0·0012
Organic nitrogen	0·05	0·03
Humus	0·80	0·60

Remarks. The soils are very deficient in available P_2O_5.

V. The Sangtara (*Citrus nobilis*, Lour.) Grove.

Soil. The following is a report by the Imperial Agricultural Chemist at Pusa on two samples of soil from the Sangtara grove :—

	0″-1′	1″-3′
Laboratory No.	31-1919	32-1919.
	%	%
Moisture (hygroscopic)	1·92	1·62
Combined moisture and organic matter and undetermined	2·65	2·02
Sand and insoluble matters	61·75	62·37
Iron (Fe_2O_3)	5·53	5·29
Alumina (Al_2O_3)	10·88	10·38
Oxide of manganese (Mn_3O_4)	0·03	0·08
Lime (CaO)	9·36	9·64
Magnesia (MgO)	0·87	0·74
Potash (K_2O)	1·12	1·02
Soda (Na_2O)	0·39	0·32
Phosphoric acid (P_2O_5)	0·16	0·16
Carbonic acid (CO_2)	7·21	7·96
Sulphuric acid (SO_3)	0·05	0·02
	100·00	100·00
Available potash (K_2O)	0·015	0·008
„ phosphoric acid (P_2O_5)	0·0016	0·0009
Organic nitrogen	0·05	0·04
Humus	1·35	1·20

Remarks. The soils are very deficient in available P_2O_5

FIG. 1.

Left

Maltas budded on *C. Aurantium*, Linn., the "sour orange" of California and Florida, the "khatta" of North-West India.

Right

Maltas budded on *C. Limonum*, Osbeck, the "rough lemon" of California and Florida, the "khatti" or "kharna" of North-West India.

Age 2 years 3 months from date of planting.

The Maltas on the rough lemon have made an excellent beginning. The Sangtaras on this stock did not start very well (Plate VIII, fig. 2).

FIG. 2.

Left

Maltas budded on *C. Limonum*, var. "sharbete," "mitha" or "sweet lime" of North-West India.

Right

Maltas budded on *C. Limonum*, var. "rough lemon" of California and Florida, the "khatti" or "kharna" of North-West India.

Age 2 years 3 months from date of planting.
Here again the "rough lemon" is markedly the better stock.

FIG. 1.

A Malta on *C. Limonum*, var. " rough lemon ", " khatti " or "kharna ": age 4 years 6 months from date of planting : crop 200 oranges : height 11 ft. 10 in.: breadth at 4 ft. from the ground, 9 ft. 6 in. The " rough lemon " stock certainly appears to give vigour and fruitfulness to the Malta.

FIG. 2.

A Malta on *C. Limonum*, var. " sharbete," " mitha " or " sweet lime ": age 4 years 6 months from date of planting : crop 25 fruits : height 5 ft. 9 in.: breadth at 4 ft. from the ground, 5 ft. 4 in. The Malta does not grow at all well on the " sweet lime ".

Yet the " sweet lime " proved the best stock for the Sangtara (*C. nobilis*, Lour.) (Plate IX, fig. 1.)

FIG. 1.

A Mal[illegible]on *C. Aurantium*, Linn., the "sour orange" of Califo[illegible]nd Florida, the "khatta" of North-West India: [illegible]s 6 months from date of planting: crop 10 oranges: [illegible]ut 5 ft. 9 in.: breadth at 4 ft. from the ground, 5 ft.

How exceedingly small and unthrifty the tree is compared with the Malta of similar age which is on the "rough lemon" (Plate II, fig. 1)?

It is extraordinary that this "sour stock", which is perhaps the most popular for the Malta or any sweet orange in America, is so unsuitable for the Malta in North-West India. In discussing stocks for the sweet or Malta orange, Swingle in the "Standard Cyclopædia of Horticulture" says: "No stock is more commonly used in the world's *citrus* regions than the sour orange. Trees propagated on it are long-lived, vigorous and produce fruit of high quality. The stock itself is resistant to mal-di-goma and some other similar diseases which affect other orange stock. Wherever it can be used it should be given preference. It is a congenial stock for all important varieties of oranges, the Satsuma (*C. nobilis*, Lour. var.) alone excepted." *Contrary to American experience the sour orange is not a suitable stock for the sweet or Malta orange in North-West India. The Sangtara or Satsuma (C. nobilis, Lour.), on the other hand, does well on the sour orange in North-West India.*

FIG. 2.

A Malta on *C. Medica*, Linn., the citron or coarse "galgal" North-West India: age 4 years 6 months from date of plantin crop 16 oranges: height 3 ft. 6 in.: breadth 3 ft. Although it used by many nurserymen, the citron gives neither vigour n fruitfulness to the Malta. On the other hand the Sangtara (*nobilis*) grows quite well on the citron. But the orang produced thereby are of very poor quality.

Left

Maltas on *C. Limonum*, var. "rough lemon," "khatti" or "kharna".

Age 4 years 6 months from date of planting.

Right

Maltas on *C. Limonum*, var. "sharbete" "mitha" or "sweet lime".

Roots of four distinct *Citrus* stocks, aged 6 years, each of which had a Malta scion or head.

Left to right (1) *C. Limonum.* var. " sharbete ", " mitha " or " sweet lime " of North-West India. (2) *C. Medica*, Linn., the coarse citron or " galgal " of North-West India. (3) *C. Limonum*, var. " rough lemon " of America, " khatti " or " kharna " of North-West India. (4) *C. Aurantium*, Linn., the sour orange of America, the " khatta " of North-West India.

The sour orange and rough lemon stocks were raised from seed in the spring of 1910. The citron and the sweet lime stocks were propagated from cuttings in the same year. The roots that are shown in the plate are typical of many that were examined.

With its great spread of strong well developed roots, the rough lemon could hardly fail to encourage a vigorous, fruitful Malta head. The roots in this picture may be compared with those in Plate XI.

The results of the tests might have been more convincing if all the stocks had been raised from seed. But the sweet lime yields few seeds, which do not germinate well ; nor do the young seedlings grow freely. On the other hand, the sweet lime and the citron are easily raised from cuttings and they grow with great vigour and fruit very heavily when they are not budded. It is noteworthy that the Sangtara grows and fruits well on the sweet lime stock which has been propagated from a cutting. (Plate IX, fig. 1 ; and Plate XI, fig. 1.)

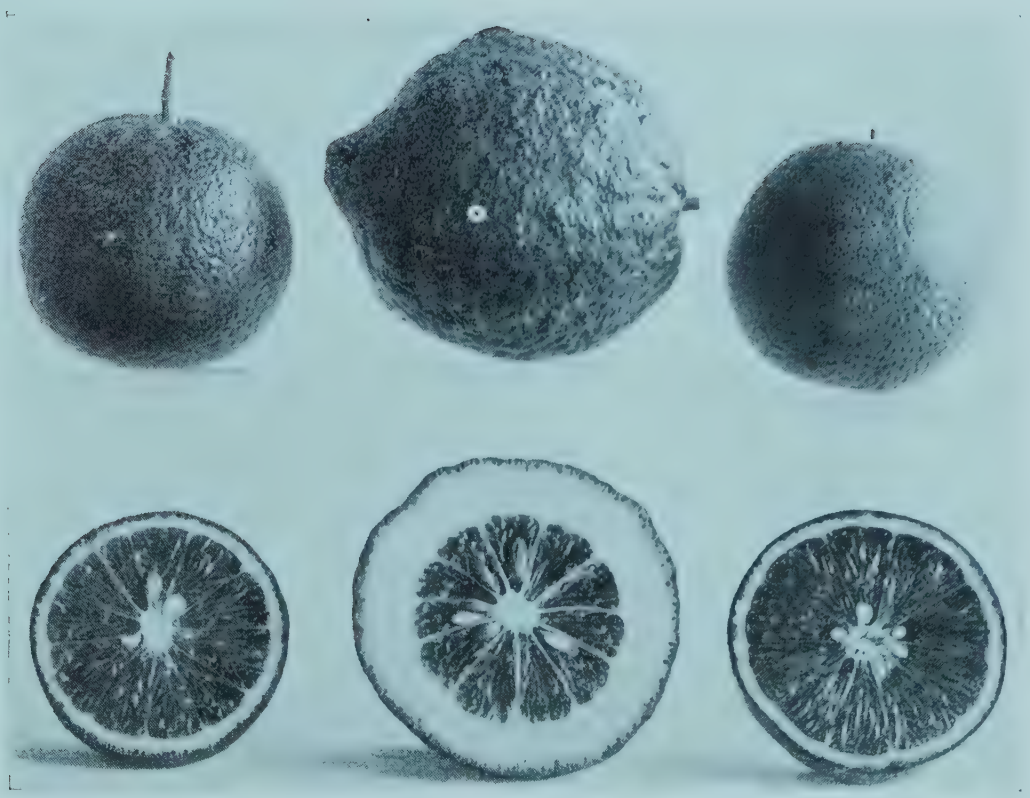


FIG. 1.

In the centre, fruits of *C. Limonum*, the "rough lemon," "khatti" or "kharna": on the right and left, Malta fruits that were grown on the "rough lemon" stock.

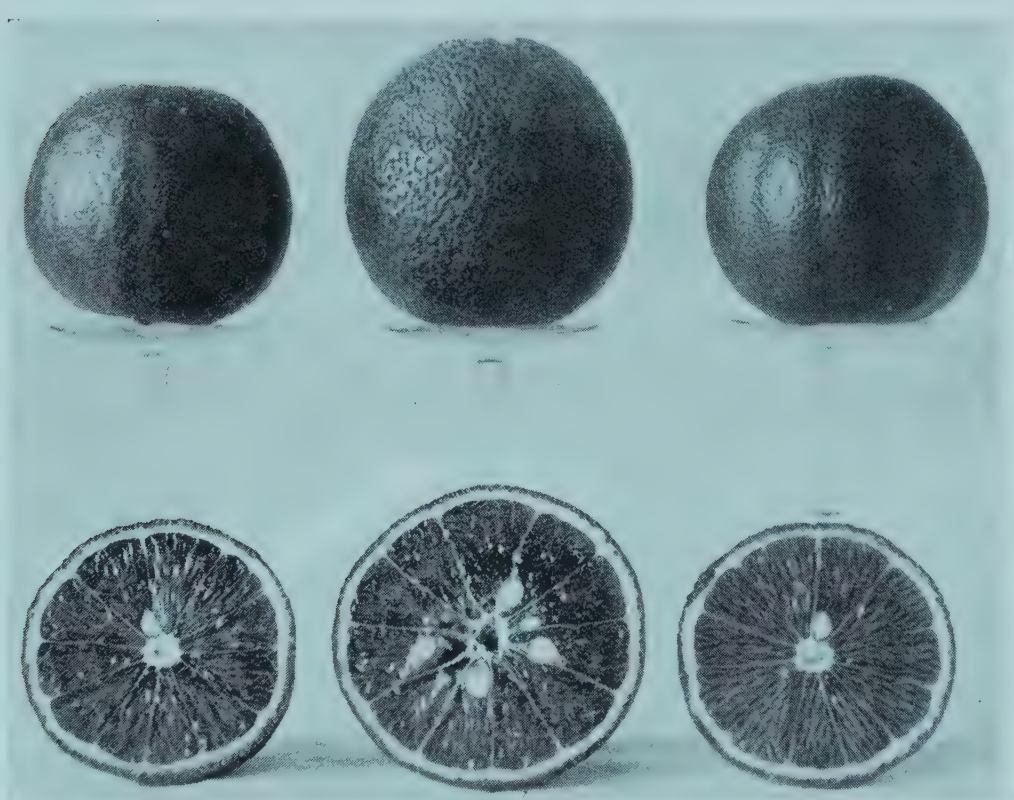


FIG. 2.

On the right and left, *C. Limonum*, var. "sharbete," "mitha" or "sweet lime": in the centre, Maltas that were grown on the "sweet lime".

The "sweet lime" has thin, clear, pale lemon-yellow, smooth skin and few seeds. The Malta in the picture has a hollow heart, but this was probably caused by the fruit having been in store for nearly two months

FIG. 1.

On the right and left are Maltas that were grown on *C. Limonum*, var. " rough lemon ", " khatti " or " kharna ": in the centre, Maltas that were grown on *C. Limonum*, var. " sharbete," " mitha " or " sweet lime ".

On the " sweet lime " stock, Malta fruits from trees which are over six years of age are generally small and, invariably, they contain few seeds.

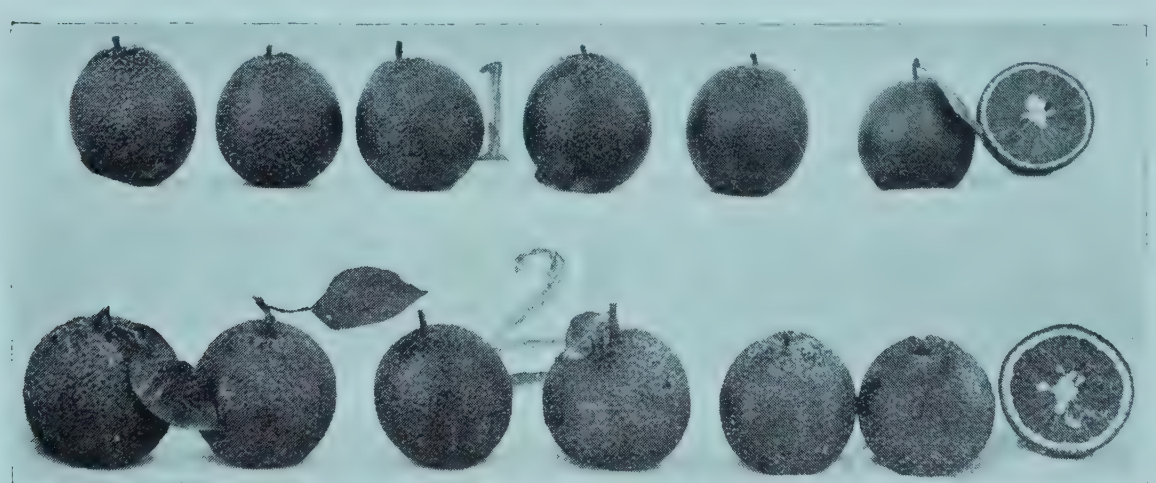


FIG. 2.

Top row. Malta oranges which were grown on the " sweet lime ", " mitha " or " sharbete " (*C. Limonum*). On this stock the fruits are smaller and have much thinner skin than Maltas which are grown on any other stock in North-West India. The oranges are distinctly oval in shape, and pale unattractive lemon-yellow in colour. The seeds average about seven in number. The juice is moderately abundant, sweet, and in flavour better than that of oranges on any of the other stocks which were used in the trial.

Bottom row. Malta oranges that were grown on the " rough lemon ", " khatti " or " kharna ". On this stock the Maltas are large and rather coarse, perfectly globular, rich attractive orange in colour and inclined to be thick-skinned. The juice is very abundant, sparkling and, on young trees especially, somewhat too acid. The seeds are numerous and large, usually numbering about sixteen or seventeen.

FIG. 1.

Left
Sangtaras budded on "sour orange," "khatta" (*C. Aurantium*, Linn.)

Right
Sangtaras budded on citron, "galgal" (*C. Medica*, Linn.).

Age 2 years 3 months from date of planting.
Unlike the Sangtara, the Malta entirely fails on the citron. (Plate III, fig. 2.)

FIG. 2.

Left
Sangtaras on "sweet lime", "mitha", or "sharbete" (*C. Limonum*).

Right
Sangtaras on "rough lemon", "khatti" or "kharna" (*C. Limonum*).

Age 2 years 3 months from date of planting.
The Malta unlike the Sangtara is more vigorous on the "rough lemon" than on the "sweet lime". (Plate I, fig. 2, and Plate IV.)

FIG. 1.

A Sangtara on the "sweet lime", "sharbete," or "mitha" (*C. Limonum*): age 7 years from date of planting. On the "sweet lime" the Sangtara is tall, and its branches, lacking strength, are easily broken by the wind or weight of fruit. At 6 years of age the crop was 500 good oranges per tree.

It is unfortunate that the "sweet lime", which gives vigour with abundant fruit of high quality to the Sangtara, only produces a weak Malta tree with, however, fruit of very high quality. (Plate I, fig. 2; Plate II, fig. 2; and Plate IV.)

FIG. 2.

A Sangtara on the "sour lime" or "khatta" (*C. Aurantium*, Linn.): age 7 years from date of planting. The picture very well shows the vigorous compact habit which the Sangtara assumes when it is budded on the "sour orange". Yet the Sangtara (*C. nobilis*, Lour.) is not satisfactory on the "sour orange" in California and Florida. The Malta, on the other hand, does well on the "sour orange" in the orange States of America, but fails entirely on this stock at Peshawar. (Plate III, fig. 1.)

FIG. 1.

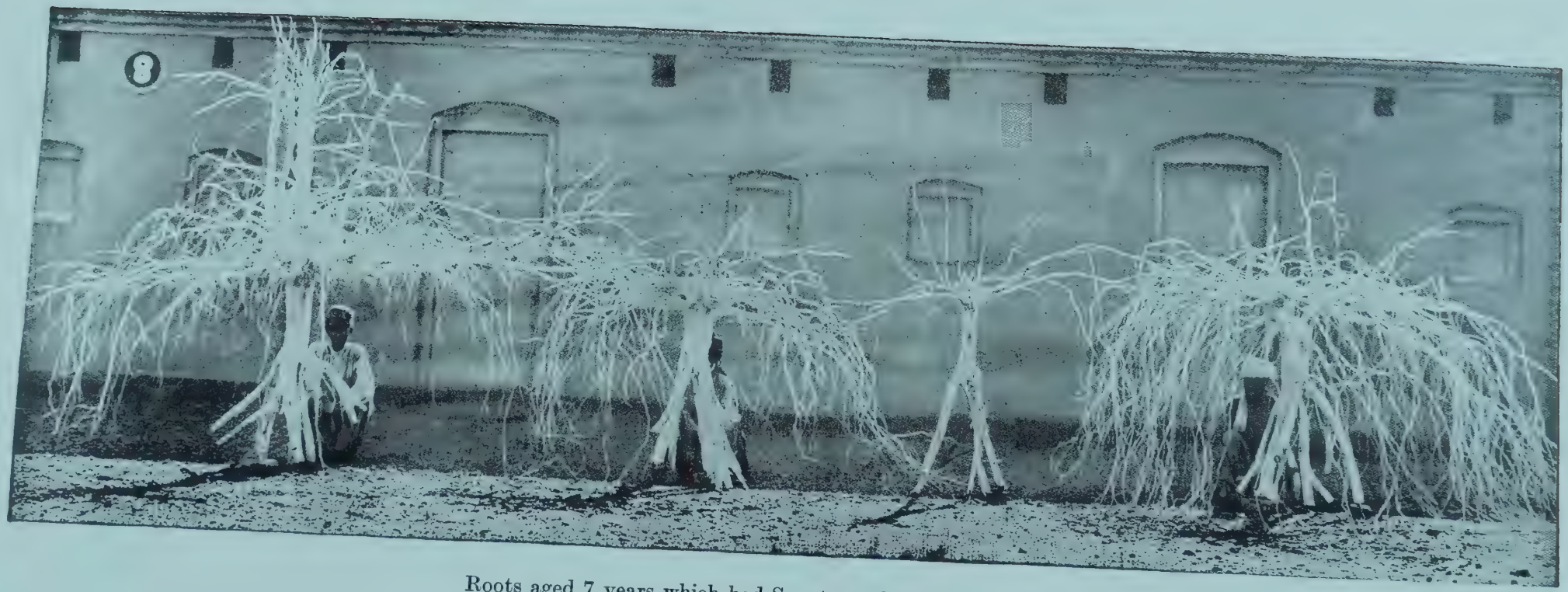
A Sangtara on the "rough lemon", "khatti" or "kharna" (*C. Limonum*, Osbeck). At the age of 7 years all of the trees in the trial were dying or dead. They began to decline after fruiting heavily in their sixth year, when the average crop per tree was 321 fruits.

It is truly extraordinary that the "rough lemon" which gives great vigour with fruitfulness to the Malta is totally unsuitable for the Sangtara. (Plate I; Plate II, fig. 1.)

FIG. 2.

A Sangtara budded on the citron or "galgal" (*Medica*, Linn.): age 7 years from date of planting. On th stock the Sangtaras were vigorous and healthy until th attained 6 years of age. Then some of the branches beg to die. Very few oranges were produced until the six year. The average crop per tree was then 440 fruits, b these were dry, flavourless and unsaleable.

It is noteworthy that the Malta hardly grows at when it is budded on the citron. (Plate III, fig. 2.)



Roots aged 7 years which had Sangtara (*C. nobilis,* Lour.) heads.

1 2 3 4

Roots aged 6 years which had Malta (*C. Chinensis*, Osbeck) heads.

1 2 3 4

Reading from left to right, (1) "sour orange" or "khatta" (*C. Aurantium*, Linn.), (2) citron or "galgal" (*C. Medica*, Linn.), (3) "rough lemon" "khatti" or "kharna" (*C. Limonum*, Osbeck), (4) "sweet lime" "mitha" or "sharbete" (*C. Limonum*).

It seems incredible that the roots numbered 1, 2, 3 and 4 in the upper and lower pictures are the same stocks, altered completely in vigour and much in habit by the scions they respectively supported. The reciprocal effects of the stock on the scion has perhaps never been more clearly shown than in these two pictures.

PLATE XI

Top row. Sangtara oranges from a tree budded on the citron or "galgal" (*C. Medica*, Linn.). The fruits were exceedingly coarse in appearance and, as they had very little juice, they were unsaleable. The average number of seeds per fruit was eight.

Second row. Sangtara oranges from a tree budded on the "sour" orange or "khatta" (*C Aurantium*, Linn.). The fruits were fairly juicy and the skin thin and tight for this class of fruit. The flavour was quite good. The average number of seeds per fruit was nine.

Third row. Sangtaras from a tree budded on the "rough lemon", "khatti" or "kharna" (*C. Limonum*). Oranges on this stock closely resembled those produced by the "sour orange" stock. The average number of seeds per fruit was ten.

Fourth row. Oranges from a tree budded on the "sweet lime", "mitha" or "sharbete" (*C. Limonum*). On this stock the fruits produced were larger and better in flavour than those on any other stock. The oranges were inclined to be too loose in skin and somewhat coarse in appearance.

VI. Summary of Conclusions.

The Malta.

Of all the orange stocks which are used by nurserymen in North-West India, the "rough lemon," "khatti" or "kharna" (*C. Limonum*, Osbeck, var.) is the one which gives greatest vigour and fruitfulness to the Malta.

The "sweet lime," "mitha" or "sharbete" (*C. Limonum*, var.), is suitable for the Malta in the small private garden only, where a dwarf tree with a few oranges of high quality are desired: the stock is unsuitable for the commercial Malta grove.

The citron or "galgal" (*C. Medica*, Linn.) and the "sour orange" or "khatta" (*C. Aurantium*, Linn.) are not suitable stocks for the Malta in North-West India.

The Sangtara.

In almost all respects the "sweet lime", "sharbete" or "mitha" (*C. Limonum*, var.) is the best stock for the Sangtara.

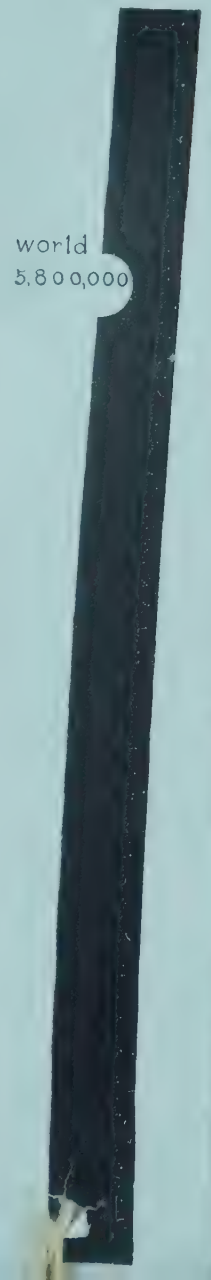
The "rough lemon," "khatti" or "kharna" (*C. Limonum*, Osbeck, var.) and the citron or "galgal" (*C. Medica*, Linn.) are not suitable stocks for the Sangtara.

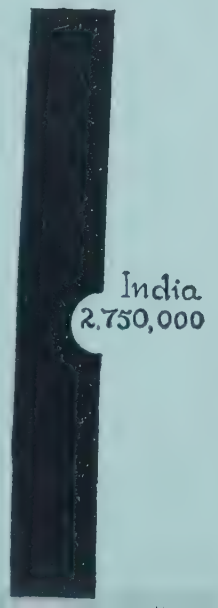
The stock and scion influence each other profoundly in producing vigour and fruitfulness in the orange tree, and in developing colour, shape, size, quality, flavour, beauty and seedlessness in the fruit.

Tests of stocks should be made wherever the orange is grown in India.

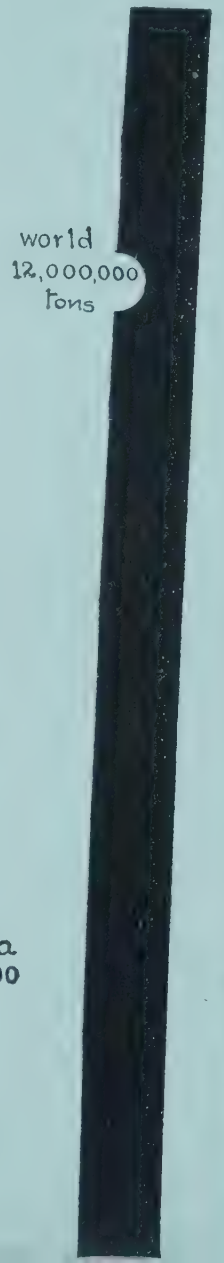
A Few Sugarcane Figures

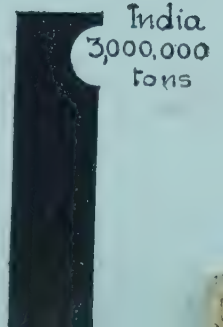
Approximate acreage harvested 1918





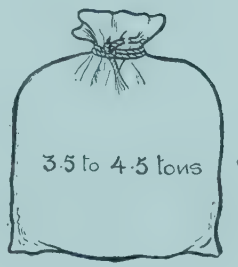
Approximate outturn of raw cane sugar 1918



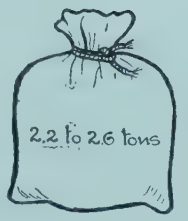


Approximate outturn of raw cane sugar per acre in different countries

Hawaii



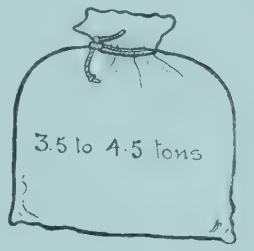
Java



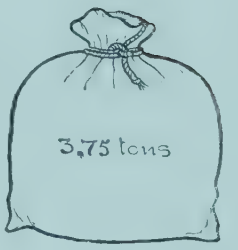
Cuba

India

Outturn of raw cane sugar per acre in Java in different years



1918



1900

1887 Seedling work.

1880

1860

A Preliminary Note on the Behaviour in North India of the First Batch of Sugarcane Seedlings distributed from the Sugarcane-breeding Station, Coimbatore.

(*Received for publication on 9th October 1919.*)

Introduction.

THE steady increase in the quantity of white sugar imported into India, together with the depressing effect which such importations, combined with their low prices, was having on the indigenous Gur (crude sugar) industry, made the Government of India, in the year 1911, direct their attention to this important industry with a view to try to put it on a satisfactory basis. The discussions on the subject, at the meeting of the Board of Agriculture in 1911, showed that the problem will have to be tackled in at least two directions, *viz.*, (1) the manufacturing or the mechanical aspect, with a view to improve the present wrong or wasteful methods; and (2) the agricultural, including the botanical aspect, with a view to improve the varieties at present grown and carry out other improvements in the methods of culture.

That the sugar industry in India is, at present, in a bad state, is evident from the figures given in the chart opposite. It is seen that, though India can boast of nearly half the world's acreage under cane, her output is only a fourth. It further contrasts the yield per acre in India with those obtained in the other cane countries, a contrast which gets all the more emphasized to India's disadvantage, when we remember that, whereas in the other countries the figures represent the quantity of refined sugar, the Indian figures are those for *gur* or *jaggery*, a more impure product. But we take heart from the fact that Java, which in the year 1860 was able to produce only about as much sugar per acre as India at the present day, has since been able to force up production in such a manner that in the year 1918 that country ranked second only to Hawaii in the matter of production per acre. In the case of India, it is doubtful, if we shall ever be able to rise to the level of the other tropical countries owing to insuperable difficulties of climate, but let us remember, that even a small increase in production will go a great way to ameliorate the position of India as a sugar-producer.

From the map of India opposite it is further evident that, to improve the Indian industry, attention will have to be concentrated on North India, chiefly the United Provinces, because (1) that province contains nearly half of India's acreage under cane, and (2) it is a vital industry in that province and sugarcane is the chief rent-paying crop, a crop "which could not easily find an equivalent in any other crop grown there." The Punjab and Bengal would come next with their one-third to half million acres under cane.

The purely botanical work, *viz.*, that of breeding a better cane for North India, was entrusted to a breeding station which in November 1912 was started at Coimbatore in the Madras Presidency under Dr. C. A. Barber, C.I.E., who was appointed Government Sugarcane Expert for all-India but with headquarters at Coimbatore. This was sought to be attained by raising canes from seed, instead of from cuttings as is ordinarily done by the ryot, a method which had already proved its utility in the other sugacane countries of the world. The difficulties experienced in previous trials at raising cane seedlings were soon overcome—in fact even before the land intended for the station was taken possession of—and we soon had a very large number of seedlings, some of them the much-desired crosses between the thin indigenous North Indian and the thick tropical kinds.[1] But it was not until the February of 1918 that the station was able to send out the first batch of selected seedlings for trial to North Indian farms.

In this bulletin are presented the results of this first year's trials. The subsequent behaviour of the Coimbatore productions, when introduced into North India, has always been a matter of anxious consideration for the station; but it is fortunate that the first year's results appear to be, on the whole, encouraging. It is thought that the results thus published will not only enable the farms to take a more intelligent interest in the growing of these seedlings, but also to offer valuable suggestions for the future work of the station, which, of necessity, had to be located far away from the area for which the seedlings are intended. The station has now reached a stage when a closer connection with the North Indian farms is needed, and constant reports on the progress of the distributed seedlings will greatly help to shape the future lines of work at the station. A few photographs are included to illustrate the growth of the seedlings in the different North Indian farms.

Selection of Coimbatore as the site for the all-India Sugarcane-breeding Station.

Though the main object of the work at the Sugarcane-breeding Station, Coimbatore, was to produce for North India a cane better than

[1] The details of this work are fully described in a Memoir by Dr. C. A. Barber, C.I.E., *Mems. of the Dept. of Agri. in India, Bot. Series*, Vol. VIII, No. 3.

Map of India showing the acreage under cane & outturn of Gur or Jaggery in the different provinces.

The shaded circles represent the acreages under cane in the different provinces and those with dots the total yield for the province in tons. The figures are for the quinquennium ending 1916-17.

the type now grown in that locality, the station itself had to be located at Coimbatore because the sugarcane rarely flowers in North India, and, even if it does, does not generally set seed. The selection of Coimbatore as a site for the station was amply justified soon after its foundation by the very large number of seedlings that it was found possible to raise there.

A minor disadvantage.

This selection—which as shown above was inevitable—carried with it one disadvantage, *viz.*, we had no knowledge as to how the seedlings bred and grown at Coimbatore might behave later when introduced into North India. This was fully recognized even at the outset, and, to gain some knowledge on this point, a set of seedlings—six in number—was introduced into North Indian farms even as early as 1914, *i.e.*, as soon as ever material was available for distribution.

The first batch of seedlings was in no way selected and consequently the various farms were requested to reject them from cultivation as soon as the first set of selected seedlings was available for distribution in February 1918. One of these, however, M.2, a Kaludai Boothan seedling raised in 1911-12, is still grown at Shahjahanpur as a wind-break on account of its good growth and habit (Plate V).

The first seedlings raised at the Station were mostly thick and hence unsuitable for North India.

During the early years of the station the varieties that flowered were mostly thick canes and we had but little control over the parents. The seedlings produced were consequently mostly thick and so unsuitable for introduction into North India. Later on, however, it was found possible to induce many of the thin canes also to flower at the station. This, together with the steadily increasing knowledge of the different parents[1] gained in the meanwhile, enabled the station to plant out, for the season 1917-18, a crop of seedlings more than 50 per cent. of which were of a type suitable to be grown in North India.[2]

The first distribution to North India was made in February 1918.

This enabled the station to send out its first batch of selected seedlings in February 1918. But a new difficulty presented itself. The final

[1] Venkatraman, T. S. "Study of arrowing in the sugarcane." *Agri. Journal of India*, Special Indian Science Congress Number, 1917.

[2] It is perhaps worth mentioning here that though it has been possible to effect crosses, between thick canes and most of the groups that occur in North India, the two classes represented by (1) Nargori, Kewali, Sararoo, etc., and (2) Mungo, Hemja, Rheora, Burli Kuswar, etc., offer special difficulties because these do not flower under Coimbatore conditions and, even if they do, produce only unhealthy flowers. These are at the same time very desirable parents, and any information on the arrowing (flowering) of these varieties in any locality will be welcome.

chemical analyses figures for the 1917-18 crop would be available only in March-April, while the North Indian farms wanted the seedlings at least in February—the general planting season in North India. At this stage the accumulated analytical experience was called in for aid. It was found that the final analyses figures varied correspondingly with the results obtained in February when the crop is on the whole immature. This justified the distribution of the seedlings on a comparative basis and saved a whole year for the work.

A statement is appended giving the distribution as made in February 1918. In response to individual requests from the different farms a certain amount of information about the parentages of the different seedlings is also included. Besides the thin seedlings and thin canes mentioned in this statement, certain thick seedlings and varieties were distributed to certain Madras farms, to Hebbal and to Manjri, but their growth in this, the first year, does not justify their inclusion in this report.

Statement showing the distribution of thin seedlings and varieties in February 1918.

(A cross mark placed against a locality indicates that the cane was distributed to that locality.)

Name of seedling or variety	Places to which distributed.									Notes on parentage, origin, etc.
	Banga-lore	Manjri	Gwalior	Gurdas-pur	Shaja-hanpore	Cawn-pore	Pusa	Sepaya	Tharsa	
Co. 201	×	×	×	×	×		×	×	×	Pansahi seedling. General collection.[1] Selfed or possible cross with M. 2 or M. 1017, two vigorous Madras seedlings of rather low sucrose.
Co. 202	×	×	×	×	×		×	×	×	Chittan seedling. General collection. "Rogue"[2] type. Chittan is a thick striped cane occurring round about Coimbatore.
Co. 203	×	×	×	×	×		×	×	×	Saretha seedling. General collection. Very likely selfed.
Co. 204	×	×	×	×	×		×	×	×	Chittan seedling. General collection. Some vigorous Naanal seedlings, which possess an abundance of healthy pollen, were flowering on the windward side; and cross-pollination with these is highly probable. Arrows of Chittan, collected under conditions, where selfing was the most likely, gave a different type of seedlings.
Co. 205	×	×	×	×	×		×	×	×	Vellai × Saccharum spontaneum. Bagged cross. The mother arrow possessed very few (2 per cent.) slightly open anthers, and as other stray pollen was kept out by enclosing the mother arrow in a muslin bag it may be taken to be a cross between the parents indicated.
Co. 206	×	×	×	×	×		×	×	×	Ashy Mauritius seedling. General collection. "Rogue" type.

Statement showing the distribution of thin seedlings and varieties in February 1918—*contd.*

Name of seedling or variety	Places to which distributed.									Notes on parentage, origin, etc.
	Banga-lore	Manjri	Gwalior	Gurdas-pur	Shaja-hanpore	Cawn-pore	Pusa	Sepaya	Tharsa	
Co. 207			×		×		×	×	×	J.213 × Saretha. Unbagged cross. The mother arrow had practically no healthy pollen, therefore not selfed. Saretha pollen was constantly dusted over the stigmas when they were receptive, so Saretha is the likeliest male parent. The mother arrow was not protected by muslin bag, so remote chances of cross-pollination with other varieties, chiefly M.2.
Co. 208		×	×		×	×	×	×	×	J.213 seedling. General collection. This variety has no healthy pollen, therefore not selfed. Likely crosses with M.2 or M.1017, two vigorous Madras seedlings of rather low sucrose which were flowering freely in the neighbourhood.
Co. 209			×		×		×	×	×	Khelia seedling. General collection. Very likely selfed. This variety possesses abundant fertile pollen and no others were flowering in the vicinity at the time.
Co. 210		×	×		×	×	×	×	×	J.213 seedling. General collection. This variety has no healthy pollen, therefore not selfed. Likely crosses with M.2. or M.1017, two vigorous Madras seedlings of rather low sucrose which were flowering freely in the neighbourhood.
Co. 211					×		×	×		Green Sport of Striped Mauritius × Saretha. Unbagged cross. The mother variety has a fair quantity of its own pollen, so may be a selfed seedling. The stigmas were constantly dusted with Saretha pollen, so Saretha is a likely male parent. With such an abundance of fertile pollen, possibility of cross-pollination with other varieties flowering in the vicinity is very remote.

Co. 212		×	×		×	×	×	×		J.213 × M.2. Unbagged cross. The mother variety has no fertile pollen, so not selfed. Probably a cross with M. 2 which was the only variety flowering in the neighbourhood at the time.
Co. 213				×	×		×	×		J.213 × Kansar. Unbagged cross. The mother variety has no fertile pollen, so not selfed. May be a cross with Kansar whose pollen was artificially dusted over the stigmas, or with M.2 which was flowering freely near by.
Co. 214				×	×		×	×		Striped Mauritius × (Saretha × Sacch. spontaneum). Unbagged crosses. Notes on parentage similar to those of Co. 211.
Co. 215				×	×		×	×		Ditto . . Unbagged crosses. Notes on parentage similar to those of Co. 211.
Co. 216				×	×		×	×		Green Sport of Striped Mauritius × Saretha Unbagged crosses. Notes on parentage similar to those of Co. 211.
Co. 1	×	×	×	×	×	×	×	×	×	Chittan seedling. General collection. This variety possesses an abundance of fertile pollen, so very likely selfed. Possibility of cross-pollination with Karun or Kaludai Boothan which were flowering freely in the neighbourhood. This is a medium thick cane of high sucrose content (over 20 per cent. in the juice in a field test).
Kassoer	×	×	×	×	×	×	×	×	×	Two indigenous canes of Java. Kassoer possesses an excellent habit and is now being used as a female parent owing to the absence of fertile pollen of its own.
Taboe Monjet.					×		×	×		Two indigenous canes of Java. Kassoer possesses an excellent habit and is now being used as a female parent owing to the absence of fertile pollen of its own.
J. 33*a*	×	×	×	×		×	×	×	×	These Java seedlings have been growing at the station from the commencement. These were distributed, partly because a few of them were reported to be doing well in North India and partly for comparison with the distributed Co. seedlings.
J. 36			×	×			×	×		These Java seedlings have been growing at the station from the commencement. These were distributed, partly because a few of them were reported to be doing well in North India and partly for comparison with the distributed Co. seedlings.
J. 139	×	×	×	×		×	×	×	×	These Java seedlings have been growing at the station from the commencement. These were distributed, partly because a few of them were reported to be doing well in North India and partly for comparison with the distributed Co. seedlings.
J. 213	×	×	×	×		×	×	×	×	These Java seedlings have been growing at the station from the commencement. These were distributed, partly because a few of them were reported to be doing well in North India and partly for comparison with the distributed Co. seedlings.
J. 247			×	×		×	×	×		These Java seedlings have been growing at the station from the commencement. These were distributed, partly because a few of them were reported to be doing well in North India and partly for comparison with the distributed Co. seedlings.

NOTE 1. "General collection" indicates that the arrows were collected in the field without any control over the male parent.

NOTE 2. "Rogue" is the term applied to a seedling of thick parentage in a "General collection", which shows a remarkable resemblance to the North Indian thin cane, being much thinner and more vigorous than the parent. (*Vide* Bateson and Pileuw, "Journal of Genetics", July 1915, page 13).

NOTE 3. In the above statement wherever crosses are involved the two parents are separated by a cross mark ; the first named represents the female parent and the second the male parent.

NOTE 4. For explanation of "Bagged" and "Unbagged" crosses see the text.

Explanation of the terms "Bagged" and "Unbagged" crosses with a short note on the methods of crossing in sugarcane current at the Cane-breeding Station.

These two terms require a certain amount of explanation for their being properly understood. Crossing in the sugarcane presents peculiar difficulties, as emasculation is practically entirely ruled out owing to the extreme delicacy of the floral structures ; even a prolonged bending of the main axis has been known to result in the complete drying up of the arrow. Fortunately, however, we have in the cane, certain varieties which are male sterile in different degrees. If this male sterility is absolute, we can, by enclosing such flowers in muslin bag and introducing into it some known pollen, obtain a cross, about the male and female parentages of which we can assume a high degree of certainty. Such a one is Co. 205. If, however, the mother shows a certain degree of male fertility and we introduce some other known pollen—keeping the arrow under bag—the resultant seedlings will either be selfed or cross-pollinated with a known father. Both these are referred to as "bagged crosses" in the above statement.

It was found, however, that bagging an arrow frequently exerted an adverse influence on its seed-setting[1]; and therefore in later years crossing was frequently done by merely marking the mother arrows in the field and keeping them constantly dusted with some known pollen till the stigmas were found to wither. These are called "unbagged crosses." In these the male parents are only probable as there is an ever-present possibility of any stray wind-borne pollen getting access to the stigmas. The parentage becomes yet more uncertain, when, as in the cases of Cos. 214, 215, and 216, the mother arrow possesses fertile pollen of its own, for there then arises three different distinct possibilities as to the parentage of the resultant seedlings.

(*a*) Selfed,

(*b*) Cross with the pollinated father,

(*c*) Cross with some unknown parent through some stray wind-borne pollen.

The above remarks may perhaps convey to the reader an impression as to the futility of parentage notes in cases like those of Cos. 214, 215 and 216, but against it the following considerations are advanced :—

(1) In the absence of more accurate information, it is an advantage to know at least the most likely parents, in following the behaviour of such seedlings in future years.

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[1] Venkatraman, T. S. "Study of arrowing in the sugarcane." *Agri. Journal of India*, Special Indian Science Congress Number, 1917.

(2) In the character of the resultant seedlings, we occasionally get some indications by which it is possible to guess the male parents with a certain degree of certainty.

(3) With the Breeding Station sanctioned only for a limited period, the purely utilitarian aspect had to be prominently kept in view, and, so far, the results would appear to justify the means employed.

Selection of types for each locality.

In the distribution an attempt was made to pick out the seedling with an eye to the cane now successfully grown in each locality, but it is felt that it will be sometime before much specialisation is possible in this direction. The annual visits by the staff of this office and the periodic reports from the different farms will, it is hoped, soon yield valuable data on this question.

A method to minimise "personal equation" in the selection work at the Cane breeding Station.

One very important qualification for a breeder is the ability to quickly compare with one another different plants or strains with a view to selection and propagation. Such a valuation has often to be made on a large number of characters and this is a matter in which " personal equation " is likely to play not an insignificant part. That this work of comparing and selecting is not a light one at the Cane-breeding Station, will be readily conceded, when it is realized that each year the station has as many as 5,000 new seedlings and 600 already selected ones, in different stages of filtration, from which to pick material for further trial and propagation.

The method described.

To systematize this work as far as possible and to guarantee that each character gets its due recognition in the final estimate a system of marking was introduced. A list was prepared of the characters considered important in forming the estimate and each allotted a maximum of ten marks. All the seedlings were then examined for some particular character at a time and marks noted against each in proportion to its merits. This process was then repeated for each of the other characters on the list and the totals made up for each seedling. A large number of marks, in the totals thus arrived at, will indicate the satisfactory nature of the seedling in most or all the characters and it is therefore safe to make the selections on this basis.

The behaviour of the distributed seedlings in the different North Indian farms during the first year of trial.

This method, having proved itself useful at the Cane-breeding Station for some time, was adopted in a tour to North India (in December 1918 to January 1919) undertaken with the special object of studying the behaviour of the distributed seedlings in that locality. Besides notes on health, height, arrowing, length of formed cane, thickness of canes, etc., marks were given for four important field characters, *viz.* :—

(1) Stand or germinating capacity.

(2) Vigour or weight of harvest.

(3) Habit. *i.e.*, whether the canes in the clump stand upright, or are slanting, or fall about in all directions seriously interfering with subsequent cultural operations. Further the straightness of canes is a character of considerable importance in (1) the transport to the factory in carts, and (2) the packing on the hoppers at the mill.

(4) Tillering, *i.e.*, the number of canes per stool at harvest. This is included in No. 2, but was thought of sufficient importance to be separately considered.

The table hereunder gives the marks obtained by each distributed seedling for the above four characters in each of the farms visited. In the remarks column will be found some tentative notes on the parentages considered likely to be useful in the different tracts.

Statement of marks obtained by the distributed seedlings in the different farms with notes on the parentages likely to be useful in the different tracts. (*See Plates I, II, III, IV, V, VI for comparison of growth*).

Co. Nos.	Sugarcane-breeding Station, Coimbatore	Bangalore	Manjri	Tharsa	Pusa	Sepaya	Cawnpore	Shahjan-pur	Gurdaspur	Remarks
Co. 201 .	32 6, 10, 8, 8.	30 8, 7, 8, 7.	36 10, 9, 10, 7.	32 9, 7, 9, 7.	28 6, 7, 8, 7.	32 9, 8, 9, 6.	..	35 8, 9, 9, 9.	23 6, 6, 6, 5.	(1) The top figure against each seedling represents the aggregate marks obtained by the seedling for all the four characters. The bottom figures represent the marks for each character, for (1) Stand. (2) Vigour, (3) Habit and (4) Tillering. The maximum for each character was fixed at ten.
Co. 202 .	39 10, 10, 9, 10.	23 6, 6, 4, 7.	35 10, 9, 8, 8.	29 7, 9, 5, 8.	24 7, 8, 3, 6.	33 9, 8, 9, 7.	..	35 10, 8, 7, 10.	33 8, 9, 10, 6.	
Co. 203 .	25 6, 7, 8, 4.	25 6, 7, 4, 8.	28 8, 6, 6, 8.	17 3, 4, 4, 6.	13 3, 4, 3, 3.	..	..	16 6, 4, 3, 3.	12 4, 1, 5, 2.	
Co. 204 .	34 8, 10, 9, 7.	25 7, 6, 6, 6.	36 10, 8, 9, 9.	25 4, 6, 6, 9.	15 3, 6, 3, 3.	29 7, 7, 8, 7.	..	32 8, 8, 10, 6.	29 7, 7, 10, 5.	
Co. 205 .	29 6, 7, 9, 7.	26 7, 6, 6, 7.	38 10, 10, 10, 8.	29 7, 8, 5, 9.	13 3, 4, 3, 3.	31 9, 9, 6, 7.	..	25 6, 7, 6, 6.	34 8, 9, 10, 7.	(2) Dots placed against a locality indicates that the seedling was not available for examination generally because of not having been distributed to that locality.
Co. 206 .	34 7, 9, 10, 8.	32 8, 8, 8, 8.	39 10, 9, 10, 10.	33 8, 8, 9, 8.	29 7, 6, 9, 7.	33 8, 7, 10, 8.	..	31 8, 7, 9, 7.	33 8, 8, 9, 8.	
Co. 207 .	31 7, 9, 8, 7.	..	..	27 7, 9, 5, 6.	15 4, 5, 3, 3.	24 8, 6, 5, 5.	..	22 6, 5, 5, 6.	..	
Co. 208 .	31 9, 8, 8, 6.	..	37 10, 9, 8, 10.	35 8, 9, 9, 9.	24 7, 9, 4, 4.	29 8, 6, 9, 6.	31 9, 7, 7, 8.	40 10, 10, 10, 10	..	(3) The distributed seedlings included two "Rogues"—Co. 202 and Co. 206—and their satisfactory behaviour in most of the farms justifies the hopes placed in them on their first appearance.
Co. 209 .	31 8, 9, 7, 7.	..	..	29 7, 9, 5, 8.	21 6, 7, 3, 5.	..	..	28 8, 7, 5, 8.	..	
Co. 210 .	32 8, 10, 7, 7.	..	36 10, 10, 10, 6.	36 9, 10, 8, 9.	28 9, 9, 3, 7.	34 9, 9, 8, 8.	31 3, 10, 8, 10.	28 6, 8, 6, 8.	..	(4) "Rogues" and Crosses with Sacch. spontaneum (Co. 205) are apparently the most promising lines for the Punjab as that tract requires the hardiest kinds.
Co. 211 .	26 8, 9, 5, 4.	..	..	..	?	23 6, 7, 5, 5.	..	17 5, 4, 4, 4.	..	
Co. 212	31 9, 8, 8, 6.	..	34 10, 8, 8, 8.	..	17 4, 5, 4, 4.	32 8, 8, 9, 7.	20 4, 4, 5, 7.	28 7, 6, 8, 7.	..	
Co. 213 .	30 8, 9, 7, 6.	..	..	..	30 7, 8, 7, 8.	28 8, 8, 6, 6.	..	30 6, 8, 10, 6.	24 6, 5, 8, 5.	(5) For the United Provinces "Rogues" Pansahi seedlings, and J. 213 crosses deserve a full trial.
Co. 214 .	30 7, 9, 7, 7.	..	..	..	20 9, 5, 3, 3.	30 10, 7, 7, 6.	..	24 7, 5, 5, 7.	26 7, 6, 8, 5.	
Co. 215 .	31 9, 9, 7, 6.	..	..	..	18 6, 5, 5, 2.	22 9, 5, 4, 4.	..	21 6, 6, 5, 4.	25 7, 4, 7, 7.	(6) But for the unfortunate tendency to smut shown by J. 213 seedlings (*vide* note elsewhere in this bulletin) this would appear to be a useful parent for Sepaya, Manjri and Tharsa.
Co. 216 .	27 8, 10, 4, 5.	..	..	..	23 6, 8, 4, 5.	32 8, 10, 5, 9.	..	19 4, 6, 3, 6.	23 6, 4, 7, 6.	(7) The seedlings showed very poor growth at Gwalior and no notes were recorded for that locality.

"Arrowing" and "smutting" of the distributed seedlings in the different farms.

Tendency to arrow and liability to smut are serious drawbacks in any distributed seedling and the statement below gives the record for the seedlings in respect of these two characters at the time of examination. The upper figure gives the note on "arrowing" and the lower one on "smutting."

Distributed Co. seedlings	Character studied	Cane-breeding Station, Coimbatore	Bangalore	Manjri	Gwalior	Tharsa	Pusa	Sepaya	Cawnpore	Shahjahanpur	Gurdaspur	Remarks
Co. 201	Ar.	Nil	Few	Prof.	conditions and no notes could be recorded.	Nil	Nil	Nil	...	Nil	Nil	(1) Note the special liability to smut in the Saretha seedling—Co. 203, and Khelia seedling—Co. 209.
	Sm.	Nil	Nil	Nil		1 sht.	Nil	Nil	...	Nil	Nil	
Co. 202	Ar.	Few	Prof.	Prof		Prof.	Mod.	1 Ar	...	Nil	Nil	(2) Seedlings with J. 213 or Saretha as either of the parents show a similar liability to smut.
	Sm.	Nil	Nil	Nil		1 sht.	Nil	Nil	...	Nil	Nil	
Co. 203	Ar.	Nil	Prof.	Nil		Prof.	Mod.	...[1]	...	Nil	Nil	
	Sm.	Few	1 sht.	Nil		Nil	1 sht.	Bad	...	Bad	Nil	
Co. 204	Ar.	Prof.	Prof.	Prof.		Prof	Nil	Nil	...	Nil	Nil	The above parents will, therefore, have to be used with very great caution in breeding cane for a locality where smut is a serious consideration.
	Sm.	Nil	Nil	Nil		Nil	Nil	Nil	...	Nil	Nil	
Co. 205	Ar.	Nil	Prof.	Prof.		Prof.	Prof.	Prof.	...	Nil	Nil	
	Sm.	Nil	Nil	Nil		Nil	Nil	Nil	..	Nil	Nil	
Co. 206	Ar.	Prof.	Prof.	Prof.		Prof.	Nil	Nil	...	Nil	Nil	
	Sm.	Nil	Nil	Nil		Ni	Nil	Nil	...	Nil	Nil	
Co. 207	Ar.	Nil	...	...		Nil	Nil	Nil	...	Nil	...	
	Sm.	Nil	...	...		Nil	Nil	Nil	...	Few	...	

Co. 208	Ar.	*Nil*	...	Few	The seedlings showed poor growth because of abnormal weather	Nil	Nil	Nil	Nil	Nil	...
	Sm	*Nil*	...	*Nil*		Nil	Nil	Nil	Few	1 sht. ?	...
Co. 209	Ar.	*Nil*	...	...		Few	Nil	...[1]	...	Nil	...
	Sm.	*Nil*	...	...		Nil	Nil	Bad	...	Bad	...
Co. 210	Ar.	*Nil*	...	Few		Nil	Nil	Nil	Nil	Nil	...
	Sm.	Few	...	*Nil*		Nil	Nil	Nil	Nil	Nil	...
Co. 211	Ar.	*Nil*	...	...		...	Nil	Nil	...	Nil	...
	Sm.	Few	...	...		...	Nil	Nil	...	Nil	...
Co. 212	Ar.	Few	...	Few		...	Nil	Nil	Nil	Nil	...
	Sm.	*Nil*	...	*Nil*		...	Nil	Nil	Nil	Nil	...
Co. 213	Ar.	*Nil*	...	...		...	Nil	Nil	...	Nil	Nil
	Sm.	*Nil*	...	...		...	Nil	Nil	...	Nil	Nil
Co. 214	Ar.	*Nil*	...	...		...	Few	Nil	...	Nil	Nil
	Sm.	Few	...	...		...	Nil	Nil	...	1 sht. ?	Nil
Co. 215	Ar.	Few	...	...		...	Nil	Nil	...	Nil	Nil
	Sm.	Few	...	...		...	Nil	Nil	...	Nil	Nil
Co. 216	Ar.	Few	...	...		...	Nil	Nil	...	Nil	Nil
	Sm	*Nil*	...	...		...	Nil	Nil	...	Nil	Nil

[1] These seedlings were destroyed at this farm owing to the appearance of smut.

Prof. = Profuse.
Mod. = Moderate in number or quantity.
Sht. = Shoot
... = The seedling was not available for observation generally because of not having been distributed.

Arrowing in canes has no immediate harmful effect on the sucrose contents, but leads to the stoppage of all further vegetative growth and the formation of pith in the centre if the crop is kept in the ground long after the arrowing. The notes on arrowing, recorded above, show that this character in a seedling need not deter us from distributing it to a place like Gurdaspur. It rises to a position of some importance when distributing to places similar to Shahjahanpur, Sepaya and Pusa, while serious note will have to be taken of this character when considering distribution to places like Manjri, Hebbal and Tharsa. (I. Plate VI.)

Similarly, tendency to smut in a seedling is not apparently a matter for serious consideration in the Punjab. It is a very serious drawback in a seedling intended to be distributed to the United Provinces, Sepaya—where the Farm Superintendent entirely destroys the crop on the first appearance of smut in the field—and Pusa. In places like Manjri, Hebbal and Tharsa it is apparently not of much account. In some of these localities the late-formed lateral shoots often regularly show smut and the crop does not appear to suffer much in consequence.

Chemical analyses of the distributed seedlings.

Lastly the sucrose contents of the seedlings is a character of great importance and the present distributions have accordingly been analysed in the different farms. It is to be remembered, however, that the analyses figures are not strictly comparable, because, (1) of the smallness of the samples analysed, (2) of the possibility that at the time of analyses the seedlings may not have been equally ripe in all the places, (3) of differences in the methods of analyses followed at the various stations. The various officers have very kindly forwarded the analyses figures for comparison and these are published in the statement herewith appended.

Character of the juice of the Coimbatore seedlings in different localities.

Locality	Co. 201				Co. 202				Co. 203			
	Brix	Sucrose	Glucose	Co-efficient of purity	Brix	Sucrose	Glucose	Co-efficient of purity	Brix	Sucrose	Glucose	Co-efficient of purity
	%	%	%		%	%	%		%	%	%	
Sugarcane-breeding Station, Coimbatore	16·82	13·45	..	80·0	14·06	10·37	..	73·8	14·12	11·13	..	78·8
Manjri	16·57	12·78	..	77·1	16·54	13·46	..	81·2	20·38	17·77	..	87·2
Tharsa (Sunnabile, 14·23 per cent. Su. in juice, Khari, 15·15 and J. 247, 16·61.)	17·82	14·52	0·51	82·0	19·06	15·46	0·76	81·4	18·56	15·68	0·32	84·7
Pusa (Maneria, 12·07 per cent. Su. in juice, Kuswar 15·41 per cent. and Rheora 13·19.)	16·23	12·90	1·24	79·6	17·31	13·34	1·42	76·9	17·91	15·21	0·61	84·9
Sepaya	..	13·74	0·63	83·9	..	14·85	0·41	87·8	..	..	..	..
Shahjahanpur (Highest sucrose in selected varieties under field conditions 13·0, average 11·0.)	..	9·96	2·09	..	..	10·21	2·31	..	..	13·19	0·78	..
Gurdaspur (The average of a number of analyses of Dhaulu was 14·60 per cent. sucrose in juice.)	..	14·23	0·97	81·9	..	13·23	1·8	81·2	..	..	..	..

	Co. 204.				Co. 205.				Co. 206.			
Sugarcane-breeding Station, Coimbatore	15·91	12·13	..	76·2	14·47	10·10	1·49	69·8	15·92	11·82	0·70	74·2
Manjri	16·94	13·40	..	79·3	17·14	13·50	..	79·1	13·58	9·52	..	70·1
Tharsa Sunnabile, 14·23 per cent. Su. in juice, Khari, 15·15 and J. 247, 16·61.	16·65	13·18	1·25	79·2	17·90	14·76	0·70	82·5	15·96	12·69	0·41	82·9
Pusa Maneria, 12·07 per cent. Su. in juice, Kuswar 15·41 and Rheora 13·19.	16·23	12·68	1·27	78·2	16·97	13·42	1·27	79·0	16·23	12·92	0·71	79·6
Sepaya	..	14·92	0·98	85·8	..	16·45	0·54	85·4	..	13·80	0·28	84·0
Shahjahanpur Highest sucrose in selected varieties under field conditions 13·0, average 11·0.	..	11·48	2·21	..	..	12·28	2·33	..	..	9·71	2·01	..
urdaspur The average of a number of analyses of Dhaulu was 14·60 per cent. sucrose in juice.	..	11·68	1·19	78·0	..	11·62	0·96	73·7	..	12·77	1·84	76·9

Character of the juice of the Coimbatore seedlings in different localities—contd.

Locality	Co. 207.				Co. 208.				Co. 209.			
	Brix	Sucrose	Glucose	Co-efficient of purity	Brix	Sucrose	Glucose	Co-efficient of purity	Brix	Sucrose	Glucose	Co-efficient of purity
	%	%	%		%	%	%		%	%	%	
Sugarcane-breeding Station, Coimbatore												
Manjri	16·24	12·81	0·31	78·9	14·27	9·97	1·28	69·9	14·59	11·68	..	80·1
Tharsa	..	..	..	..	17·01	12·86	..	75·7	..	..	..	..
Sunnabile, 14·23 per cent. Su. in juice, Khari, 15·15 and J. 247, 16·61.	19·36	17·68	0·15	91·1	20·80	18·27	0·13	89·6	18·72	15·34	0·18	83·4
Pusa												
Maneria, 12·07 per cent. Su. in juice, Kuswar 15·41 and Rheora 13·19.	18·34	15·84	0·23	86·3	17·50	14·51	0·63	82·8	17·10	14·19	0·37	83·0
Sepaya												
Shahjahanpur	..	15·26	0·23	93·6	..	16·33	0·51	89·4	..	..	..	..
Highest sucrose in selected varieties under field conditions 13·0, average 11·0.	..	12·48	0·92	..	..	11·67	1·83	..	..	11·57	1·42	..
Gurdaspur												
The average of a number of analyses of Dhaulu was 14·60 per cent. sucrose in juice.	..	..	..	..	..	..	..	..	..	..	..	..

Locality	Co. 210				Co. 211				Co. 212			
Sugarcane-breeding Station, Coimbatore												
Manjri	16·57	13·33	..	80·5	14·93	11·74	..	78·7	17·34	14·31	..	82·5
Tharsa	18·34	14·93	..	81·5	..	..	..	..	17·04	13·53	..	79·3
Sunnabile, 14·23 per cent. Su. in juice, Khari, 15·15 and J. 247, 16·61.	19·10	16·24	0·14	86·9	..	..	..	..	..	..	..	..
Pusa												
Maneria, 12·07 per cent. Su. in juice, Kuswar 15·41 and Rheora 13·19.	17·94	15·31	0·50	85·5	15·97	13·15	1·15	82·5	18·40	16·13	0·53	87·5
Sepaya												
Shahjahanpur	..	17·06	0·39	88·9	..	16·04	0·32	88·6	..	15·42	0·20	90·2
Highest sucrose in selected varieties under field conditions 13·0, average 11·0.	..	8·17	2·32	..	..	11·37	1·94	..	..	9·32	2·32	..
Gurdaspur												
The average of a number of analyses of Dhaulu was 14·60 per cent. sucrose in juice.	..	..	..	..	..	..	..	..	..	..	..	..

Character of the Juice of the Coimbatore seedlings in different localities.

Locality.	Co. 213				Co. 214				Co. 215				Co. 216			
	Brix.	Sucrose.	Glucose.	Co-efficient of purity.	Brix.	Sucrose.	Glucose.	Co-efficient of purity.	Brix.	Sucrose.	Glucose.	Co-efficient of purity.	Brix	Sucrose.	Glucose.	Co-efficient of purity.
	%	%	%		%	%	%		%	%	%		%	%	%	
Sugarcane-breeding Station, Coimbatore . .	15·80	12·13	..	76·1	19·46	16·22	..	83·4	17·04	13·71	0·82	80·5	15·69	12·24	..	78·1
Manjri	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Tharsa	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Sunnabile, 14·23 per cent. Su. in juice, Khari, 15·15 and J. 247, 16·61.																
Pusa	18·34	15·69	1·01	85·6	18·88	16·56	0·48	87·9	17·50	14·45	0·85	82·5	14·99	11·68	1·07	78·0
Maneria, 12·07 per cent. Su. in juice, Kuswar 15·41 and Rheora 13·19.																
Sepaya	..	15·25	0·34	85·2	..	18·67	0·28	93·0	..	16·24	0·29	88·0	..	18·09	0·40	95·3
Shahjahanpur	..	8·73	2·61	..	..	12·56	1·35	..	..	11·92	1·71	..	..	11·14	1·97	..
Highest sucrose in selected varieties under field conditions 13·0, average 11·0.																
Gurdaspur	..	13·11	1·02	80·7	..	17·98	0·37	87·3	..	12·74	0·96	78·1	..	15·19	1·22	83·8
The average of a number of analyses of Dhaulu was 14·60 per cent. sucrose in juice.																

NOTE 1. All available analyses figures are given in this statement.
NOTE 2. Dots indicate that the figures are not available generally because of the seedling not having been distributed.
NOTE 3. At the cane-breeding station the seedlings were analysed three times and the highest figures are here recorded. Some of the analyses did not include glucose determinations and hence the absence of these figures in a few cases.

Co. 202 Co. 201

Co. 204 Co. 203

Co. 206 Co. 205

Coimbatore seedlings at the Gurdaspur Farm. The variety seen behind is Dhaulu, a dwarf local cane. Note the comparative better growth of the Coimbatore seedlings.
The gauge seen in the pictures has alternate foot spaces marked black and white and is placed to enable comparison of height of growth.

Co. 210 Co. 209 Co. 208

Coimbatore seedlings at the Tharsa Farm. The growth was so good that some of them had to be heavily supported with bamboos.

J. 247 Khari and Sunnabile (at the Tharsa Farm.)

Some of the promising canes grown by the local Agricultural Department.
The gauge seen in the pictures has alternate foot spaces marked black and white and is placed to enable comparison of height of growth.

Co. 215 Co. 208 Co. 202

Co. 202 Co. 201

Coimbatore seedlings at the Cattle-breeding Station, Sepaya.
Note the free growth and satisfactory habit.
The gauge seen in the pictures has alternate foot spaces marked black and white and is placed to enable comparison of height of growth.

The tall row of canes seen in the picture is that of Co. 210 grown at the Cawnpore Farm. The growth is very promising.

The bulk crop seen in the picture is of J. 33a grown at Cawnpore for seed. To the left are seen a few rows of Ashy Mauritius.

The gauge seen in the pictures has alternate foot spaces marked black and white and is placed to enable comparison of height of growth.

A cane plot at the Shahjahanpur Sugarcane Research Station. The two rows to the right are of M. 2, a Madras seedling raised in 1911-12. This seedling has a low sucrose but is grown as a wind-break because of its good growth and excellent habit.

Coimbatore seedlings at the Pusa sugarcane area.

From left to right; Karun, Cos. 207, 206, 205, 204, 203, 202, 201, and Kuswar. Karun is a thick cane introduced from Coimbatore, and Kuswar a thin dwarf North Indian cane. Note the comparative better growth of the Coimbatore seedlings. Some of these have arrowed freely here. The gauge seen in the pictures has alternate foot spaces marked black and white and is placed to enable comparison of height of growth.

Arrowing of the distributed seedlings at Manjri Farm.

Co 204 Co. 203 Co. 202

Arrowing of the distributed seedlings at Tharsa Farm.
The gauge seen in the pictures has alternate foot spaces marked black and white and is placed to enable comparison of height of growth.

A Note on the Treatment of Surra in Camels by Intravenous Injections of Tartar Emetic

(Received for publication on 3rd December, 1919.)

In the early part of 1917, I carried out experiments with tartar emetic in connection with the treatment of surra in camels. Six camels were finally submitted to treatment, and the results obtained may be of interest to those at present working on surra in camels and other animals.

From the 27th August, 1917, to the 22nd July, 1919, these camels were kept under observation by Captain Pool, I.A.R.O., who during this period was in charge of the laboratory. I am indebted to him for the daily blood examination and the care of these camels during this time.

Camel No. 1. Obtained from the 53rd Silladar Camel Corps, Sargoda. Aged 8 years. Condition poor.

Received the following treatment :—

1917		
June 2nd .	200 c.c. of a 1 per cent. solution of tartar emetic intravenously.	Fed well.
June 3rd .	Do.	Fed well.
June 4th .	250 c.c. of a 1 per cent. solution of tartar emetic intravenously.	Fed well.
June 5th .	Do.	Fed well.
June 6th .	Do.	Fed well.
June 7th .	Do.	Fed well.

After the last dose the camel went off feed and did not feed normally for two days.

The camel never did well and died on 14th October in an emaciated condition 129 days after treatment finished but no trypanosomes reappeared in the blood.

Camel No. 2. Obtained from the 53rd Silladar Camel Corps, Sargoda. Condition poor. Aged 9 years.

Received the following treatment :—

1917		
May 26th .	600 c.c. of a 1 per cent. solution of tartar emetic intravenously.	Shortly after injection respiration became very rapid. Off feed.
May 27th .		Off feed.
May 28th .		Off feed.
May 29th .		Off feed.
May 30th .		Fed fairly.
May 31st .		Fed fairly.
June 1st .		Fed well.

This camel continued to feed well but never improved in condition.

An injury to the leg necessitated an operation on November 21st, from which he did not recover.

No trypanosomes reappeared in the blood since treatment finished (179 days).

Camel No. 3. Obtained from the 52nd Silladar Camel Corps, Jhelum. Condition poor. Aged 7 years.

Received the following treatment :—

1917		
May 23rd .	250 c. c. of a 1 per cent. solution of tartar emetic intravenously.	Fed well.
May 24th .	Do.	Fed well.
May 25th .	Do.	Fed well.

On the morning of 26th the camel was off feed and did not feed well for 4 days ; after this he fed well and improved greatly in condition. Died on July 14th, 1919, as result of falling down a Khud in the grazing ground.

This camel worked constantly from 15th January, 1919, to 1st May, 1919, carrying a load of 5 maunds 24 miles one day and 14 the next, or an average of 19 miles a day.

Two hundred and forty-one days after treatment finished one guinea pig and one rabbit were inoculated with blood from this camel but remained healthy.

No trypanosomes reappeared in the blood since treatment finished (780 days).

Camel No. 4. Obtained from the 54th Silladar Camel Corps, Lahore. Condition fair. Aged 7 years.

Received the following treatment :—

1917		
May 23rd .	200 c.c. of a 1 per cent. solution of tartar emetic intravenously.	Fed well.
May 24th .	Do.	Fed well.
May 25th .	250 c.c. of a 1 per cent. solution of tartar emetic intravenously.	Fed well.
May 26th .	Do.	Fed well.
May 27th .	Do.	Fed well.
May 28th .	Do.	Fed fairly.

For three days after the last dose the camel did not feed well, but after this he fed well and improved in condition.

Two hundred and thirty-eight days after treatment finished one guinea pig and one rabbit were inoculated with blood from this camel, but remained healthy.

Died on 23rd October, 1919, whilst being castrated.

No trypanosomes reappeared in the blood since treatment finished (513 days).

Camel No. 5. Obtained from the 65th Government Camel Corps, Campbellpur. Condition poor. Aged 9 years.

Received the following treatment :—

1917		
May 18th .	200 c.c. of a 1 per cent. solution of tartar emetic intravenously.	Fed well.
May 20th .	250 c.c. of a 1 per cent. solution of tartar emetic intravenously.	Fed well.
May 22nd.	Do.	Fed well.
May 24th .	Do.	Fed well.
May 26th .	Do.	Fed well.
May 28th .	Do.	Fed well.
May 30th .	Do.	Fed well.
June 1st .	Do.	Fed fairly.
June 3rd .	Do.	Fed fairly.
June 5th .	Do.	Fed fairly.

For five days after the last dose the camel fed only fairly but after this he fed well and improved in condition.

Two hundred and thirty days after treatment finished one guinea pig and one rabbit were inoculated with blood from this camel, but remained healthy.

From 15th January, 1919, to 1st May, 1919, this camel worked constantly, carrying a load of 5 maunds 24 miles one day and 14 next, or an average of 19 miles a day.

No reappearance of trypanosomes for 887 days since treatment finished (November 8th, 1919).

Condition (November 8th, 1919) good.

Camel No. 6. Obtained from the 52nd Silladar Camel Corps, Jhelum. Condition fair. Aged 8 years.

Received the following treatment :—

1917		
March 20th.	60 c.c. of a 1 per cent. solution of tartar emetic intravenously.	Fed well.
March 22nd .	Do.	Fed well.
March 24th .	Do.	Fed well.
March 26th .	Do.	Fed well.
March 28th .	Do.	Fed well.
March 30th .	Do.	Fed well.
April 1st .	Do.	Fed well.
April 3rd .	Do	Fed well.
April 5th .	Do.	Fed well.
April 7th .	Do.	Fed well.

This camel fed well during the whole of the treatment.

Two hundred and eighty-nine days after treatment finished one guinea pig and one rabbit were inoculated with blood from this camel, but remained healthy.

This camel worked continuously from 15th January, 1919, to 1st May, 1919, carrying a load of 5 maunds 24 miles one day and 14 miles the next, or an average of 19 miles a day.

No reappearance of trypanosomes for 945 days since treatment finished (November 8th, 1919).

Condition at present time (November 8th, 1919) good.

Summary.

	Number of days trypanosomes absent since treatment finished	Condition
	Days	
Camel 1.—Died from debility	129	Very poor.
Camel 2.—Died as result of operation . . .	179	Poor.
Camel 3.—Died as result of fall in grazing ground .	780	Very good.
Camel 4.—Died whilst undergoing castration . .	513	Good.
Camel 5.—Alive	887	Alive, good condition.
Camel 6.—Alive	945	Alive, good condition.

Remarks.

(1) From these experiments one may justly conclude that camels Nos. 3, 4, 5 and 6 were cured and that tartar emetic gives promise of success in the treatment of surra; but before tartar emetic can be definitely stated to be a cure for surra, a large number of animals must be submitted to treatment, so that definite conclusions can be arrived at.

(2) Great care has to be exercised when injecting tartar emetic, owing to the fact that if any of the solution, instead of being injected into the vein, is injected subcutaneously, sloughing results.

(3) Injection of tartar emetic is liable to cause fainting; it must be injected slowly at blood heat.

I have found that—

(*a*) fainting is not so liable to occur if the injection is given during the intervals between the paroxysms, *i.e.*, when the temperature is not high,

(*b*) large doses, say 600 c.c. of a 1 per cent. solution, can be safely given in one day to fully grown camels if the amount is given in 3 injections with 2-3 hours' interval between the injections; whereas in the majority of cases if 600 c.c. of a 1 per cent. solution is given in one injection death results.

A Summary of the Experiments on Rice in Bihar and Orissa from 1912 to 1919

(Received for publication on 19th January, 1920.)

THE various experiments which are summarised in this paper were carried out in order to discover the best methods of cultivating rice in Bihar and Orissa both from the point of view of outturn and of profit. They were mostly undertaken on land which could be irrigated at least occasionally and are concerned with questions of ploughing, seed selection, sowing, transplanting and manuring. As is usually the case with a summary of experiments which has to be given at a specified date, some of the questions investigated have not yet been sufficiently examined, in others the results are indefinite; nevertheless various conclusions may be drawn.

For the sake of clearness I have divided the paper into four parts.

A. Introduction.

B. A summary of the experiments in cultivation.

C. A summary of the experiments in the use of manures.

D. Conclusions that, I think, may be drawn.

A. Introduction.

Although experiments were carried out before 1912-13, I have thought it preferable to commence with that date because up to that time there was only one Deputy Director in charge of all the farms in the province (which is roughly the size of France), and it was impossible for him to give the experiments close personal supervision. The consequence was that as the farm staffs were for the most part untrained in experimental work and lacking in the spirit of impartial scientific enquiry many of the results were inaccurate.

I arranged the experiments on the Bankipore and Dumraon Farms up to 1916-17 inclusive, after which they were designed by Mr. Robinson, Assistant Director of Agriculture; on the Cuttack Farm up to 1915-16, after which they were designed by Mr. Sethi, Deputy Director of Agriculture; on the Sabour Farm in 1912-13, after which Mr. McGowan, the Professor of Agriculture, was responsible, though the majority of the rice experiments there were actually carried out by Mr. Sil, the Assistant Professor of Agriculture. In certain experiments I have recorded the results in a different form to that in which they were given in the yearly farm reports, and have sometimes drawn different conclusions from them.

1. Explanation of the tables.

In the following tables the outturns are given in pounds per acre, the profits in rupees and annas per acre.

A deficit or loss is shown by prefixing a *minus* sign (—).

A *maund* is 82 lb., a *seer* (one-fortieth of a *maund*) is taken as 2 lb.

In all cases where the outturn is entered without the name of the crop, the crop is rice. Unless otherwise stated the rice was some variety of the main crop harvested in December, and was transplanted.

It is important that an experiment should be tested on a variety of plots and for several seasons. In those tables which show the average results, therefore, I have recorded the number of trials (*i.e.*, the total number of plots), the area (*i.e.*, the sum of the area of all the plots) and the number of years during which the trials were carried out. In the same tables the average outturn in pounds per acre produced by each treatment was arrived at as follows :—The records available were usually the average results for each year reduced, for the sake of conformity, to pounds per acre, with a note as to the number and size of the plots ; but the number and size of the plots varied from year to year. I have multiplied these recorded results by the area of the plots in their respective years, added the products together and divided by the total area in acres.

When the average results are given in the body of the report the results of each year will be found in the appendix.

In certain cases the profits resulting from an experiment are given, but these should not be regarded as more than an indication of what may be expected. Naturally the results will vary in different circumstances. The figures given were obtained from the farm books and include the cost of the seed, manures, labour (both of men and animals) and so forth on the one side, and on the other the value of the outturn at the then market rates. No allowance has been made for rent, purchase and depreciation of implements, or the wages of the Superintendent or superior farm staff other than the mates (foremen actually in charge of the coolies). For practical purposes these figures seem sufficient. They show that as a result of actual experiments a field, which unmanured or untreated brought in A rupees, after the addition of a manure or special treatment brought in A *plus* or *minus* X rupees when all extra expenses had been deducted. Questions of rent, depreciation *etcetera* do not arise as they are common to the treated and untreated field: the important point is the *plus* or *minus* X rupees. It should however, be remembered that a ryot almost invariably pays less in cultivation charges than a Government farm in the same district and any profit obtained is therefore likely to be larger. And further, at the present

moment (the end of 1919) the value of the crops has increased since the first experiments recorded much more than the price of labour.

2. The *paira* crop.

Although the main object of these experiments is to discover their effect upon the rice yet whenever the rice was followed by a *paira* crop, the details of the latter have been included, except in those cases (such as when varying numbers of seedlings were transplanted) in which the treatment applied to the rice could not appreciably influence the *paira*.

The *paira* is a cold weather crop broadcast in the mud amongst the standing paddy in October on the heavier rice lands of most parts of Bihar. No extra cultivation beyond sowing is required and the crop, which owing to the fact that it is then low, is unharmed when the rice is harvested in December is gathered in due course in March. Several crops are grown in this manner but they are nearly always leguminous—perhaps the most common being *khesari*, lentils, small peas, gram and linseed or some mixture of these.

The average profit from 16 unmanured fields during four years on the Bankipore Farm was, from the rice Rs. 22-10 per acre, from the *paira* Rs. 20-1. So that, on suitable land, the *paira* is of almost equal value to the rice. In obtaining this average the whole cost of the cultivation, such as ploughing, puddling and so forth has been charged to the rice, only the cost of the seed, broadcasting and harvesting the *paira* being charged to that crop. But as the ploughing and puddling would have been necessary for the rice in any case, the *paira* can be looked upon as a very valuable bye-product.

As the *paira* is nearly as valuable as the rice, the effects on it of manures applied to the rice ought to be considered, and the *paira* outturns have been included for that reason.

And further, the possibility of introducing a *paira* crop on lands on which it is not at present grown should be carefully considered, for it follows that if by the addition of some simple manurial prescription a good *paira* crop can be grown on such lands the value of the outturn will be nearly doubled at once. Unfortunately up to the present very little attention has been paid to this point. The problem was attacked at Dumraon (see table 33 and the following remarks) and was apparently solved, but the experiments were not completed. It would, I think, be advisable to put down a complete manurial series on every farm containing rice lands on which a *paira* is not grown, and sow a *paira* in each plot with careful notes of the results. If the addition of certain elements enabled the *paira* to grow, it might

be found possible to obtain them in a cheap form. For example, at Dumraon it seems almost certain that potash is required; possibly the same is true as regards Cuttack Farm where the chemical analysis shows that the percentage of potash is low. If it is found that the addition of potash enables a good *paira* crop to be grown in these districts the discovery of potassic salts in Orissa should render the manure available at a comparatively low cost if it prove impossible to supply it cheaply as ashes.

Too much reliance, however, cannot be placed on manurial results as shown in a *paira* crop until the experiments have been made on a large number of plots, as they are subject to more than the usual number of factors likely to mask the effect of the manures; for example, small inequalities in the surface of the rice field made at the time of puddling or otherwise will cause the water to stand longer in certain parts and render the germination of the *paira* uneven.

3. The farms.

Four farms are dealt with in this report, Bankipore, Cuttack, Dumraon and Sabour.

Bankipore Farm. This farm was situated immediately south of Patna Junction Station in Bihar on heavy dark soil typical of a large part of the Patna District and particularly of the low lying area south of the Ganges Bank on which the East Indian Railway main line is built. It was almost entirely rice land.

The following chemical analysis of the soil was made by Mr. Taylor, the Agricultural Chemist to the Government of Bihar and Orissa :—

Particulars.	North of the distributary		South of the distributary	
	Surface soil per cent.	Sub-soil per cent.	Surface soil per cent.	Sub-soil per cent.
Insoluble matter	76·96	73·84	75·60	73·85
Potash	0·82	0·82	0·80	0·83
Soda	0·82	0·82	0·50	0·52
Lime	1·89	1·65	0·82	1·32
Magnesia	1·38	1·96	0·73	1·17
Iron aluminium	14·46	17·06	17·24	18·32
Phosphorous pentoxide	0·25	0·30	0·17	0·13
Sulphur trioxide	trace	trace	trace	trace
Carbon dioxide	trace	trace	trace	trace
Combined moisture and organic matter*	3·42	3·55	4·23	3·36
Total	100·00	100·00	100·00	100·00
* Containing nitrogen	0·07	0·055	0·065	0·043

Cuttack Farm. This farm is situated about 6 miles from Cuttack in Orissa on the Taldana Road. The soil is a sandy loam and typical of much of the land in the Cuttack delta. The greater part of the area is rice land.

The following table gives the chemical analysis of the soil.

Particulars.	Surface soil (first 9 inches), per cent.	Sub-soil (second 9 inches), per cent.
Insoluble silicates and sand	86·66	84·33
Ferric oxide	3·74	4·83
Alumina	5·52	6·37
Lime	0·30	0·39
Magnesia	0·59	0·41
Potash	0·24	0·33
Soda	0·03	0·17
Phosphoric acid	0·03	0·03
Sulphuric acid	0·01	0·007
Carbonic acid	0·05	0·06
Organic matter and combined water *	2·83	3·07
TOTAL	100·00	100·00
* Containing nitrogen	0·004	0·004

Dumraon Farm. This farm is situated in Bihar on land lying either side of the East Indian Railway main line just east of Dumraon Station. The soil is a sandy loam. There is very little rice land.

Sabour Farm. This farm is at Sabour about 4 miles east of Bhagalpur in Bihar. The soil of the rice lands on the farm is fairly heavy, the following details are given by Mr. Taylor, the Agricultural Chemist to the Government of Bihar and Orissa and were deduced from 70 samples of soil.

	Per cent.
Nitrogen in its organic form	0·07
Available P_2O_5	0·011
Available K_2O	0·011

B. Cultivation experiments

The experiments have tested to a greater or lesser extent a number of common practices and, speaking broadly, the general result has been to show that the cultivator is right in his methods. This is what one would expect, for, on the face of it, changes in the way of cultivating the crop which increase the yield without adding to the cost or requiring new implements, would almost certainly have been discovered by the cultivators themselves in the course of the many generations during which they have been growing rice. It is not usually wise therefore, to devote too much time or space to this class of enquiry if the first few results show the present practice to be sound. Conversely, it is absolutely necessary to proceed cautiously should it appear that a mere change in the method results in a distinct improvement. The new process should be studied under varying conditions and particularly over a number of seasons, for an initial success may be due simply to the fact that the test was carried out under the best conditions and in a good year.

Of course these remarks do not apply to the introduction of obvious improvements, in vogue in well cultivated areas, to ignorant and backward cultivators such as jungle tribes. In such cases the Agricultural Department has the opportunity of carrying out at once what under modern conditions would take place of itself in a comparatively short space of time historically speaking; but opportunities of this kind are unlikely to occur in the rice tracts of Bihar.

Besides dealing with experiments which tested the value of existing practices, this part also includes experiments designed to compare the results of ordinary methods of cultivation with other methods depending upon facts or implements beyond the knowledge of the cultivator. For example, the use of seed grain that sinks in a saturated salt solution and the case of an improved plough. The average cultivator is not likely to discover for himself that a salt solution will float heavier grain than pure water, and would not willingly incur the expense of an improved plough unless he was sure it would be to his advantage in the end.

1. Hot weather cultivation.

Taking the province as a whole the rice lands are not as a rule cultivated during the hot weather. North of the Ganges they are usually ploughed, and the cultivators there say that this reduces the weeds and improves the yield. South of the river, on the other hand, the ryots more commonly leave them uncultivated from harvest

time until they are puddled preparatory to transplanting, as they maintain that the weeds which grow up during the interval rot, when turned under water, before the rice is transplanted and thus benefit the crop, that is, they prefer to keep the weeds and utilise them as a green manure. On some of the low-lying heavy lands, however, there are certain weeds which do not die when the land is puddled, and these are occasionally checked by ploughing the surface during the hot weather.

TABLE I.

(*Bankipore.*)

NUMBER OF		Total area in acres	Ploughed in the hot weather with a	AVERAGE INCREASE OVER THE UNPLOUGHED PLOTS			
				RICE		GRAM	
Trials	Years			Grain	Straw	Grain	Straw
13	4	2·4	Punjab plough . .	113	99	183	161
5	3	0·8	Hindustan plough .	89	11	219	188
9	4	1·6	Local plough . .	29	43	85	108

TABLE II.

(*Cuttack.*)

NUMBER OF		Total area in acres	Treatment	AVERAGE	
Trials	Years			Grain	Straw
4	2	0·8	Ploughed in the hot weather.	1,219	1,883
4	2	0·8	Unploughed . .	1,066	1,414

The Bankipore table above shows that hot weather cultivation on land south of the river in Patna distinctly increases the yield of the rice and still more of the *paira* when carried out with a plough having a share and mould board (such as the Punjab or, to a less extent, the Hindustan) though there is only a little extra yield of rice from cultivation with the local plough. It is probable that this last fact explains the ryot's neglect of the practice, especially if the increase in his *paira* was not associated with the hot weather ploughing, as is quite possible.

At Cuttack, in Orissa, hot weather cultivation has increased the yield.

Definite figures from land north of the river would be useful for comparison ; while a series is required to show whether the increased yield is maintained over a number of years at the same figure or whether, as is more probable, there is a fall in the proportional increase when the same land is ploughed every year, though not back to the original outturn from unploughed land.

Still we may say that it certainly pays, and is better farming, in Patna, Cuttack, and probably elsewhere, to invest in a plough such as the Punjab or some similar make and to plough the land at least once with it during the hot weather to aerate the soil and kill the weeds, rather than to leave it unploughed.

2. Seed selection.

Table III.

(*Cuttack.*)

Seed sown	Average of duplicate trials in two years	
	Grain	Straw
Seed that did not pass through sieve . . .	1,754	2,583
Corresponding unselected seed	1,743	2,413
Seed that sank in a saturated salt solution . . .	2,011	2,531
Corresponding unselected seed	1,799	2,480

Two simple methods of seed selection were tried, in one case the seed was rubbed over a sieve of such a size that it let through about half the sample—the larger seeds which did not pass through were sown, in the other case the seed was thrown into a saturated solution of salt in water and the seeds which floated were rejected.

It will be seen that seed selected in the former way gave an increased outturn of 0·6 per cent. of grain only, but seed selected by the salt solution produced an increase of 11·8 per cent.; that is selection by weight is much better than selection by size.

Selecting seed in this way is simple and inexpensive and will well repay the cultivator, the rejected seed that floats can be sold and the salt from the brine given to the cattle.

3. Transplanted and broadcast rice compared.

It is a well known fact that transplanted rice gives a larger outturn and is more profitable than broadcast, and the following trials bear this out.

Table IV.

(*Sabour.*)

Cultivation	1915-16	
	Grain	Straw
Transplanted	939	3,466
Broadcast	475	2,388

The experiments were carried out in triplicate on 0·1 acre plots, the figures are the average of the three plots.

Table V.

(*Cuttack.*)

Number of		Total area in acres	Cultivation	Average			
Trials	Years			Grain	Straw	Cost	Profit
						R a.	*R a.*
8	4	1·6	Transplanted . .	1,545	2,013	22 5	27 11
8	4	1·6	Broadcast . .	1,237	2,004	23 6	16 7

It will be noticed that the expenditure at Cuttack on broadcast rice was Rs. 1-1-0 per acre more than on transplanted. In Bihar the reverse is the case, transplanting costing considerably more than broadcasting. The following examples from non-experimental fields on the Bankipore Farm give definite figures (they were selected by opening the farm books at random).

	Cultivation charges per acre	Grain per acre	Straw per acre
1915-16.			
	R a. p.		
5·1 acres transplanted	25 0 4	629	672
8·7 acres broadcast	19 1 5	511	907
1916-17.			
5·8 acres transplanted	18 12 3	1,430	1,905
7·4 acres broadcast	14 11 5	562	735

This shows that the cultivation cost in Bihar is Rs. 5 per acre more when the rice is transplanted. The fact that the difference between the yield is less and the cost of broadcasting more in proportion at Cuttack than in Bihar is probably due to the system of cultivating broadcast lands in Orissa, referred to in the next section.

The Bankipore figures given above cannot be considered so reliable as the others when comparing the yields (though as a comparison of the cost of the two methods they are perfectly fair) because the fields were selected by chance from the books instead of being selected as of equal value on the land, and the operations were not necessarily carried out at the same time, nevertheless they have the advantage of being actual figures of comparatively large areas of similar land under field conditions on one farm, and may therefore be taken as approximately correct. With the above proviso, the following is the additional yield from transplanted rice on the three farms.

At Bankipore, Bihar ; 92 per cent. of grain and 57 per cent. of straw.

At Sabour, Bihar ; 98 per cent. of grain and 45 per cent. of straw.

At Cuttack, Orissa ; 25 per cent. of grain and ·4 per cent. of straw.

Another point worth considering is the yield in each case from a given weight of seed. The seed rate per acre of broadcast land in Bihar is about 30 lb., in Orissa about 80 lb. The seed rate per acre of seed bed is about 500 lb., and, as one acre of seed bed transplants ten acres of land, the seed rate per acre of land transplanted is about 50 lb. Therefore, from the tables given above it follows that from 1 lb. of seed is obtained—

16 lb. when broadcast, or 19 lb. when transplanted at Sabour.

18 lb. when broadcast, or 21 lb. when transplanted at Bankipore.

15 lb. when broadcast, or 31 lb. when transplanted at Cuttack.

The greater difference between the two at Cuttack is due to the method of growing broadcast rice in Orissa where many seedlings are uprooted. But considering the results in Bihar alone, where no seedlings are destroyed, it appears that although there may be rather better germination in the seed bed than in the field this does not account for the difference, and it follows that the plants benefit from the check of uprooting and transplanting them.

But, it may be asked, if the money return and the yield from transplanted rice is greater, why then do the ryots who, of course, are quite aware of this, broadcast any land at all. They do so for a mixture of reasons. Some lands while too low for dry crops are too high for transplanted rice, which requires more water, and are therefore put down under broadcast rice. Others again are too low, and are liable to be flooded too deep by the heavy rains shortly after transplanting so a rice

is broadcast which has more chance of keeping above water. Also, and more important in the rice tracts, it is usually impossible to transplant the whole area owing to lack of labour. The seed beds are sown at the commencement of the rains and the sowing period cannot be extended for long (see section 5) while if the seedlings are not transplanted within a fairly definite time after they are sown the yield falls off considerably (see section 8), but transplanting is slow and laborious work, about ten labourers being required to transplant an acre in one day, and everyone wants to transplant at nearly the same time. Thus the area that can be commanded is restricted. The cultivators usually transplant as much as they can.

4. Broadcast rice in Orissa.

(In this section and this section only, the figures of yields refer to broadcast rice.)

The cultivation of broadcast rice is not uniform throughout the Province. In Bihar the land is prepared as for any other crop and sown at the rate of 15 *seers* (30 lb.) of seed per acre, the after cultivation consisting of weeding when necessary. Throughout Orissa and the greater part of Chota Nagpur, on the other hand, the seed rate is very much higher, never less than 30 *seers* (60 lb.) usually 40 *seers* (80 lb.) and even as much as 60 *seers* (120 lb.). The land is not prepared so well, but when the crop is about a month old it is ploughed through with the local plough. The cultivators state that this checks the weeds, thins the crop and loosens the soil ; and this is correct as there is a great improvement in the rice after it has been ploughed through. But (as we have seen in section 3) though the yield of broadcast rice in Orissa more nearly approaches that of transplanted rice than it does in Bihar it costs more and the method is proportionally less economical.

The merits of the two systems require careful investigation. Some enquiry has already been made, but not sufficient.

Table VI.

(*Cuttack*)

Number of		Total area in acres	Seed rate per acre	Average	
Trials	Years			Grain	Straw
14	6	2·8	40 *seers* (80 lb.) . .	1,795	2,767
14	6	2·8	30 *seers* (60 lb.) . .	1,810	2,569
14	6	2·8	20 *seers* (40 lb.) . .	1,905	2,785

In these experiments the crop was ploughed through according to the local practice, and the results show clearly that the seed rate can be reduced with advantage, thereby effecting a considerable saving in seed grain and also increasing the yield. It occurred to me, however, that this was due to the better preparatory cultivation of the land on the government farm compared to that of the local cultivators, and that the ploughing through could be omitted in the former case. This was tested in the series given below.

TABLE VII.

(*Cuttack.*)

NUMBER OF		Total area in acres	Seed rate per acre	After treatment	AVERAGE	
Trials	Years				Grain	Straw
4	2	0·8	40 *seers* (80 lb.) .	Ploughed through .	1,518	2,157
4	2	0·8	30 *seers* (60 lb.) .	Do. . .	1,420	1,896
4	2	0·8	20 *seers* (40 lb.) .	Do. . .	1,551	2,580
4	2	0·8	15 *seers* (30 lb.) .	Not ploughed .	1,637	2,777

These experiments as far as they go, show that it would be better to follow the Bihar custom in Cuttack. A further trial was made later.

TABLE VIII.

(*Cuttack.*)

Seed rate per acre	Preparation before sowing	Treatment after sowing	1917-18			
			Grain	Straw	Cost of cultivation	Profit
					R a.	*R a.*
35 *seers* (70 lb.) .	Ploughed 5 times.	Ploughed through.	1,650	4,047	24 13	24 0
35 *seers* (70 lb.) .	Do. .	Not ploughed .	1,455	4,405	30 9	14 15
25 *seers* (50 lb.) .	Do. .	Do. .	1,537	3,946	28 2	17 14
25 *seers* (50 lb.) .	Ploughed 10 times.	Do. .	1,778	5,227	31 9	23 11

The experiments were in duplicate on 0·2 acre plots, the figures are the average of the two plots.

On this occasion a larger yield was obtained with a comparatively low seed rate on the better cultivated land, but the higher seed rate and the local cultivation proved slightly more profitable. It would,

however, have been better as a test of the two methods had the seed rate been reduced, if not to the 15 *seers* of Bihar, at least to the 20 *seers* that have so far proved the best on this farm.

On the whole the evidence available up to date appears to me to be in favour of not ploughing through. But there is another advantage in the Orissa custom, though it is one quite unknown to the local cultivators; that is to utilise the system to apply a green manure to the broadcast rice.

TABLE IX.

(*Cuttack.*)

Number of		Total area in acres	Treatment	Average		
Trials	Years			Grain	Straw	Profit
						R a.
6	3	1·2	Green manure (*dhaincha*) .	1,710	2,481	28 10
6	3	1·2	Unmanured	1,456	2,327	22 3

In these experiments 10 lb. of *dhaincha* (*Sesbania aculeata*) per acre were mixed with the rice seed before sowing, and the whole sown together. When the crop was ploughed through a month later most of the *dhaincha* plants were uprooted and those that were not were pulled up and forced into the mud, as are other upstanding weeds, by the gang that goes through the fields after the ploughing through. This proved beneficial and profitable.

The two questions have not yet been examined in conjunction to find out whether it pays better to prepare the land well, reduce the seed rate and not plough through, or to retain the high seed rate, mix in *dhaincha* and plough through. The evidence, though insufficient as yet, is in favour of the latter as it has given a larger increase per cent.

5. Loss from late rains and late sowing.

Every one knows that if the rains are late the rice crop is poor, but any information as to the relation between the time of sowing and the decrease of the crop should be of use to those interested in the gross outturn. Probably the best way of arriving at correct figures would be to transplant the same area for a number of years with seedlings of the same variety sown at the first favourable rainfall, recording the date and the yield. But this would involve other questions, such as the nature of the rainfall each year, and, possibly, variations in the soil, while in any case it would take a long time to arrive at satisfactory figures.

In order to obtain some idea of the loss due to late transplanting only, I arranged a series at Bankipore and Sabour in 1912, in which the seed was sown and the seedlings transplanted at intervals of half a month, thus artificially approximating later and later rains, while the land used could be irrigated when necessary, thus eliminating any difficulties due to breaks in the rains. I have only recorded the dates of transplanting, but the seeds were sown about 5 weeks earlier in each case.

TABLE X.

Transplanted on	BANKIPORE		SABOUR		AVERAGE		LOSS PER CENT	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
July 10th 1912 . .	1,379	2,793	1,708	6,999	1,543	4,896	0	0
July 25th 1912 . .	1,107	2,298	1,767	4,048	1,437	3,173	6·87	35·19
August 10th 1912 . .	1,066	2,246	1,517	3,196	1,291	2,721	16·33	44·42
August 25th 1912 . .	954	2,052	1,353	3,162	1,153	2,607	25·28	46·75
September 10th 1912 .	724	1,537	1,116	2,650	920	2,093	40·38	57·25

Each transplanting was on 6 plots of 0·2 acre each, the figures are the average of 6 plots ; the figures in the column of averages are thus based on 2·4 acres each.

These trials show that a delay of a fortnight beyond the usual time (in this case the first sowing was about June 5th) means a loss of nearly 7 per cent. of grain, a delay of a month 16 per cent. loss, while if the rains are delayed until the first week in August the loss is over 40 per cent. The loss of straw is larger in each case.

These figures, of course, can only be taken as approximate.

6. WET AND DRY SEED-BEDS.

Two kinds of seed-beds are sown. In one the seed-bed is puddled under water before sowing and kept wet, in the other the seed is sown in moist land in the same way as other crops.

TABLE XI.

Cultivation	SABOUR			CUTTACK			SABOUR		CUTTACK	
	NUMBER OF		Total area in acres	NUMBER OF		Total area in acres	AVERAGE		AVERAGE	
	Trials	Years		Trials	Years		Grain	Straw	Grain	Straw
Wet seed-bed . .	16	3	0·4	6	3	1·2	1,372	...	1,778	3,155
Dry seed-bed . .	16	3	0·4	6	3	1·2	1,325	...	1,647	2,955

The above trials show an increased yield in favour of a wet and puddled seed-bed of 3·5 per cent. of grain at Sabour and 7·9 per cent. at Cuttack. The cost of cultivation in each case is about the same, the average for the two years 1916-17 and 1917-18 at Cuttack being Rs. 25-5 per acre for a dry and Rs. 25-6 per acre for a wet seed-bed. Therefore a wet seed-bed is more profitable.

The cultivator prefers a wet seed-bed, but he is dependant to a great extent upon the weather. The seed is sown at the commencement of the rains and any undue delay in sowing decreases the outturn very much more than the difference between the two types of seed-bed (section 5). The cultivator, therefore, sows his seed in a dry seed-bed if he cannot obtain sufficient water at sowing time to enable him to puddle it. He can, of course, influence this to some extent by his choice of the position of his seed-beds.

7. Seed rate in the seed-bed.

Table XII.

(*Sabour.*)

Seed rate per acre of seed-bed	1913-14 Grain
1 *maund* (82 lb.)	1,120
4 *maunds* (328 lb.)	1,625
8 *maunds* (656 lb.)	2,110
16 *maunds* (1,312 lb.)	1,670

On single 0·1 acre plots.

Table XIII.

(*Sabour.*)

Number of		Total area in acres	Seed rate per acre of seed-bed	Average
Trials	Years			Grain
3	3	0·3	2 *maunds* (164 lb.)	1,195
3	3	0·3	4 *maunds* (328 lb.)	1,159
3	3	0·3	10 *maunds* (820 lb.)	1,166

TABLE XIV.

(*Bankipore.*)

Number of		Total area in acres	Seed rate per acre of seed-bed	Average	
Trials	Years			Grain	Straw
12	3	2·7	5 *maunds* (410 lb.)	747	980
12	3	2·7	7·5 *maunds* (615 lb.)	636	964

TABLE XV.

(*Cuttack.*)

Number of		Total area in acres	Seed rate per acre of seed-bed	Average	
Trials	Years			Grain	Straw
9	3	1·8	3 *maunds* (246 lb.) .	1,301	1,846
9	3	1·8	4 *maunds* (328 lb.) .	1,484	2,028
9	3	1·8	5 *maunds* (410 lb.) .	1,543	1,879

In every series, while the different plots were transplanted from seed-beds sown with varying quantities of seed, the same number of seedlings were transplanted in each plot.

In the first year's trials at Sabour (table 12) 1 *maund* gave by far the lowest outturn, 4 and 16 *maunds* each gave about the same and 8 *maunds* higher than either ; therefore the best weight must be between 4 and 16.

Table 13 shows that the results from 2, 4 and 10 *maunds* are all about the same. At first sight, from this table alone, it might appear that it would therefore pay best to sow 2 *maunds*, but the results may equally mean that the optimum rate lies between 4 and 10 *maunds*, and taking the other tables into consideration this is the correct interpretation.

The Bankipore series (table 14) shows that the best seed rate is below 7·5 *maunds*.

The Cuttack experiments (table 15) clearly show that 4 *maunds* give a larger yield than 3, and 5 than 4.

Taking the 4 tables together therefore, we find that the best seed rate lies between 5 and 7·5 *maunds*. As a matter of fact the cultivator's usual seed rate is about 5 to 7 *maunds* per acre of seed-bed depending on the soil and local conditions. The experiments show that this is correct and should not be either reduced or increased.

This might have been expected, because the cultivators must have experimented in innumerable trials in past years.

From one point of view, however, the results are surprising. An officer, commenting on the Cuttack series, when he heard that while different seed rates were sown in the seed-beds the same number of seedlings were transplanted in each plot said, " If this is so, it is almost inconceivable that the thinner sown and presumably stouter seedlings would give much the smallest yield per acre." It is curious. Nevertheless the cultivator transplants approximately the same number of seedlings in a given area on each occasion, and it is nearly inconceivable to suppose that if by the simple and economical process of sowing less seed he could increase his yield, he would not do so. It would appear, therefore, that just as we have seen that the yield is increased by the check of transplanting so it is necessary to crowd the seedlings to some extent in the seed-bed probably to check root development before transplanting.

8. Time at which to transplant the seedlings.

Table XVI.

(*Cuttack.*)

Age of seedlings	1916-17		1917-18		1918-19		Average	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
20 days old . . .	994	2,121	979	1,845	1,296	2,203	1,090	2,056
30 days old . . .	920	1,588	1,317	2,306	1,397	2,149	1,211	2,014
40 days old . . .	1,045	2,121	1,465	2,716	1,579	2,536	1,363	2,458

Each year the experiments were carried out in duplicate on 0·1 acre plots, the figures are the average of the two plots.

The cultivator usually transplants his seedlings when they are five to six weeks old. The above table shows that at any rate it is unwise to transplant them when they are younger than this.

9. The number of seedlings to transplant in each hole.

Table XVII.

(Bankipore.)

Number of		Total area in acres	Number of seedlings	Average	
Trials	Years			Grain	Straw
10	3	2·1	1 in each hole . .	746	1,209
46	7	9·8	2 in each hole . .	994	1,824
46	7	9·8	4 in each hole . .	1,070	1,916
46	7	9·8	8 in each hole . .	1,187	2,161

Table XVIII.

(Cuttack.)

Number of		Total area in acres	Number of seedlings	Average	
Trials	Years			Grain	Straw
10	5	2	1 in each hole . .	1,873	3,169
10	5	2	2 in each hole . .	1,964	3,156
10	5	2	4 in each hole . .	2,003	3,501
10	5	2	8 in each hole . .	1,913	3,705

Table XIX.

(Sabour.)

Number of		Total area in acres	Number of seedlings	Average	
Trials	Years			Grain	Straw
161	5	4·1	1 to 2 in each hole .	1,414	...
161	5	4·1	4 to 6 in each hole .	1,577	...

In certain parts of India, particularly Madras, a large saving has been effected by transplanting single seedlings instead of bunches as was the local practice, and a number of experiments have been carried out at Bankipore, Cuttack and Sabour to ascertain whether a similar saving was possible in this province. From the results recorded above it is obvious that it is not possible in Bihar. The fact that two seedlings have given a slightly better result than eight, and four than both at Cuttack show that a small number of seedlings may possibly succeed in Orissa, but further investigation is advisable as the number of trials and the total area of the experiments at Cuttack were less than on the other farms.

At Sabour, where Mr. Sil, the Assistant Professor of Agriculture, carried out many series, and to a less extent at Bankipore, the possibility of succeeding with one or two seedlings under special conditions was carefully examined. Trials were made with early and late sowings, with thickly and thinly sown seed-beds, from wet and dry seed-beds, in heavily manured and unmanured land, etc., but I have not burdened this report by recording all these experiments in detail as they led to no definite results, the total outturn varied as might be expected but the largest number of seedlings gave the highest yield.

On the other hand the average cultivator can probably effect a certain saving if he takes the trouble to plant bunches more regular in number, at present though he hardly ever puts less than eight into a hole frequently bunches of over 20 can be found. No experiments, however, have been made as yet to ascertain the number at which the yield begins to fall off again.

10. The distance apart at which to transplant the seedlings.

Table XX.

(*Sabour.*)

Number of		Total area in acres	Distance apart	Average	
Trials	Years			Grain	Straw
3	3	0·15	6 inches . . .	1,146	4,162
3	3	0·15	9 inches . . .	1,186	3,595
3	3	0·15	12 inches . . .	919	2,768
3	3	0·15	18 inches . . .	454	2,125

The cultivator usually transplants his seedlings from six to nine inches apart, and the above table shows that this is correct.

11. Nigar.

Nigar means literally "putting off." It is used by the cultivators in Bihar in connection with running water off the fields; *e.g.*, the process of running the water out of the *ahars* to dry them preparatory to *rabi* cultivation, or the draining of the rice fields.

The water is usually run out of the rice fields twice, shortly after transplanting and again in the *utra nichchattra* which usually falls between the 12th and 24th of September. This section is concerned with this last *nigar* which is of importance on the area irrigated by the Sone Canals.

If the fields are dried shortly after transplanting no particular strain falls on the canal for two reasons, firstly because the fields are not all

drained at the same time but more or less in rotation as they are transplanted, secondly because less water is generally required to fill them up again as the time is usually one of heavy rainfall. The *utra nigar*, however, is different. It is done by rule at the beginning of the *utra* and is applied to all rice, transplanted and broadcast, early and late. The land is left to dry throughout the *nichchattra*, and at the commencement of the next *nichchattra*, the *hathia*, every field is filled up again. It is this that throws a strain on the canal. As the canal authorities point out, if the practice could be done away with, or even if it could be modified, the use of the canal would not be limited by the necessity of delivering a maximum supply on a given date and it could, therefore, irrigate a larger area of the country.

After discussions with various Public Works Officers, a series of experiments were drawn up to commence in 1916 and to be carried out on canal lands under the supervision of the Irrigation and Agricultural Departments, officers of both departments being present at and reporting on each operation. Before describing these I will recapitulate the questions involved as they appeared to me.

It may be assumed that *nigar* is beneficial for at least four reasons. (1) Theoretically it is probably advantageous to dry and aerate the soil. (2) It is the custom, not only on the canal irrigated lands, but also in those parts of Gaya and Patna irrigated by the indigenous system of pines and *ahars*,* except when there is so little reserve water that there is a danger that the fields cannot be refilled. (3) Even on the canal lands, where water is assured, the practice involves a certain amount of work in opening and closing the fields, and no one does unnecessary work. (4) Both the Irrigation and the Agricultural Departments had carried out experiments previously which showed that *nigar* was beneficial.

On the other hand it is probably not necessary to *nigar* on a given date. The cultivator has no doubt found that the *utra* is about the best time for the majority of his rice, the main crop harvested in December, but besides this his rice includes varieties such as *sirhunti* harvested in October and *kartika* harvested in November. If nigarring them at this time did harm they would be nigarred earlier, and conversely if it did them good the nigarring time of the main crop could be varied without doing much damage.

Thus the series should at least include main crop varieties nigarred at different times and *kartika* nigarred a month earlier than the usual time. (I find that unfortunately in the experiments the *kartika*

* See the author's paper "Indigenous Irrigation Works in Bihar and their improvement" in the *Agricultural Journal of India*, Vol. XI, Part II.

was nigarred a month later than usual instead of a month earlier, and as this is tantamount to no nigarring, I have excluded the result. The mistake was possibly due to my giving insufficient instructions as I was unaware at the time that I should be unable to supervise the experiments personally.

If it could be proved that small variations in the time of nigarring caused no appreciable loss, the canal authorities would be justified in insisting on different blocks of the canal irrigated land being nigarred and filled up again on different dates, and they would then have extra water to supply further areas.

Definite knowledge could not be obtained in one year even if the experiments were carried out over a large area, for variations in the rainfall must influence the result. It was necessary, therefore, to continue the experiments for a sufficient number of years to represent a fair average.

This has not yet been done, but the results of three seasons given below are very encouraging.

TABLE XXI.

Number of		Total area in acres (about)	Kind of rice	Treatment	Average	
Trials	Years				Grain	Straw
16	3	3	Main crop harvested in December	Nigarred at the usual time . .	1,422	1,950
				Not nigarred	1,373	1,901
				Nigarred at the usual time *khari* salt .	1,460	1,884
				Not nigarred *khari* salt . . .	1,519	2,080
				Nigarred at the usual time but not allowed to dry enough to crack the soil.	1,325	1,679
				Nigarred on September 1st . .	1,303	1,739
				Nigarred on September 15th . .	1,181	1,612
				Nigarred on October 1st . . .	1,119	1,599
				Nigarred on October 15th . .	1,268	1,909
				Ngarred at any time the weather permits from September 1st to October 15th.	1,275	1,773
				Nigarred at any time the weather permits from September 1st to October 15th but not allowed to dry enough to crack the soil.	1,310	1,897
10	3	1·8	*Kartika* harvested in November.	Nigarred at the usual time . .	1,353	1,645
				Not nigarred	1,341	1,768

There was a heavy fall of rain during the nigarring period of 1917 and the plots did not dry. This has a considerable effect on the figures which are the average of three years only. Of course, such years should be included, but they should not form one-third of the whole.

The first two experiments show that *nigar* is beneficial, though the increase is only 3·6 per cent. It will probably be found to be larger when the average of a number of years is taken.

In the last two nigarring is shown to benefit *kartika* rice also but to a less extent. The increase in this case is almost negligible being only ·9 per cent. Here again the percentage of gain should be larger after a longer trial including a smaller proportion of unfavourable years, but it is improbable that *kartika* when nigarred at the same time as the main crop varieties will derive as much benefit from the process as they do.

The third and fourth experiments were included to test the action of *khari* salt, which was added to both just after the water was run out of the niggared plot. From table 21 it appears that the addition of this salt has more than made good the loss due to not nigarring but a reference to table P in the appendix shows that this is due to the extraordinary (and probably incorrect) firgures of the first series at Ageon in 1918. If these are omitted *khari* salt is found to have no effect.

Comparing number five with number one it appears, as would be expected, that it is better to dry the soil completely ; but this result is contradicted in numbers ten and eleven. This would, naturally, take longer to decide than the other points, as it is more dependent on the weather.

The most important plots in the series are numbers six to nine, where the period of *nigar* is varied from September 1st to October 15th. Of these September 15th is practically the customary time. Up to the present they show that no harm results if the water is run off at any time between these dates and run in again after the usual interval. In other words they justify the canal authorities in dividing up the area into blocks to be nigarred on varying days between these dates, and thereby conserving water for irrigating land at present outside the canals.

C. Manurial experiments.

I have divided this part into chemical manures and simple manures for convenience in reference. But, while as a rule the section on chemical manures contains those manures which are relatively expensive and difficult to obtain, and that on simple manures describes those which are usually cheaper and more easily available, no definite line can be drawn between the two. The value of the manures in each case depends upon their power of supplying the plants with the same elements, and some manures (for example, saltpetre and bonemeal) though included among the chemical manures are easily obtained in certain tracts.

1. Chemical manures.

Table XXII.

(Bankipore.)

Manure applied per acre	1915-16							Residual results in 1916-17						
	Rice			Gram			Year's profit	Rice			Kerao			Year's profit
	Grain	Straw	Profit	Grain	Straw	Profit		Grain	Straw	Profit	Grain	Straw	Profit	
			Rs. a.			Rs. a.	Rs. a.			Rs. a.			Rs. a.	Rs. a.
160 lb. of ammonium sulphate	1,648	2,788	17 8	331	276	8 14	26 6	1,497	1,905	28 1	795	758	28 1	56 2
120 lb. of superphosphate	1,585	2,808	31 0	433	322	12 11	43 11	817	1,260	5 4	894	751	30 7	35 11
100 lb. of muriate of potash	1,374	2,019	13 1	484	350	15 6	28 7	295	627	12 0	575	430	17 6	5 6
160 lb. of ammonium sulphate + 100 lb. of muriate of potash.	1,876	3,024	12 11	633	491	22 5	35 0	1,372	1,652	21 10	972	793	33 1	54 11
160 lb. of ammonium sulphate + 120 lb. of superphosphate	1,886	3,372	23 2	402	308	11 4	34 6	1,667	2,090	34 2	1,001	892	35 6	69 8
120 lb. of superphosphate + 100 lb. of muriate of potash.	1,420	2,422	10 11	482	360	15 4	25 15	792	1,092	5 5	754	688	25 9	30 14
Unmanured	1,028	1,545	12 5	413	336	12 3	24 8	205	435	16 4	682	587	21 14	5 10

The experiments were in duplicate on 0·2 acre plots, the figures are the average of the two plots.

TABLE XXIII.

(Bankipore.)

Manures applied per acre	1918-19		
	RICE		
	Grain	Straw	Profit
			Rs. A.
164 lb. of superphosphate	1,165	2,120	28 3
410 lb. of bonemeal	1,360	2,485	29 10
Unmanured	1,330	2,965	51 11

The experiments were in duplicate on 0·2 acre plots, the figures are the average of the two plots.

Table 22 is interesting in that all the manures paid for themselves in the year of their application, if both crops are taken into account, notwithstanding their relatively high price in 1915.

While the series was only carried out in duplicate and for one year and is therefore not so reliable as would be a number of trials spread over several years, yet certain deductions can be made as to the value of the three classes of manures on this soil, and these deductions have much more weight if borne out not only by a comparison of two plots with two plots but by combining the results of the whole series of 14 plots into two groups for each manure.

Ammonia is clearly shown to be a valuable manure for rice. The two plots treated with ammonium sulphate have given a large increase over the unmanured plots. Again, when the six plots that received ammonium sulphate are compared with the eight plots that did not, the manure is shown to have given an increase of 33 per cent. of grain and 39 per cent. of straw. A small part of this increase is due to the sulphur as we shall see when discussing *khari* salt in the next section.

At first sight its residual effects on the rice (in 1916-17) appear extraordinary, the plots manured with ammonia the previous year giving an increase over the others of 187 per cent. of grain and 121 per cent. of straw. But, while this manure has a considerable residual effect, this enormous increase is only indirectly due to it. The plots were

flooded for a short time in 1916 and the impetus given to the plants by the nitrogenous dressing, besides making them stronger, made them slightly taller, so that they were both able to stand the immersion better and were under water for a shorter time. Nevertheless, although the actual increase in this case is largely a matter of luck, there is the other side of the question, had the plants not been given this extra help they would not have been taller and stouter and would not have received less damage than the rest—while short floods are frequent in this low-lying rice tract.

The *paira*, a leguminous crop, is not likely to be affected by a nitrogenous manure, and the outturn of the gram on the six plots manured with ammonium sulphate was the same as that on the eight plots that were not; the average figures are 455 lb. of grain per acre in the former case and 453 lb. in the latter.

Superphosphate has given good results, its application producing a large increase of rice over the unmanured plots. A comparison of the six plots treated with superphosphate with the eight plots not so treated shows an increase due to this manure of 10 per cent. of grain and 22 per cent. of straw.

Its residual results are also considerable. The six plots to which superphosphate was added in the previous year giving an average increase over the eight to which it was not added of 30 per cent. of grain and 28 per cent. of straw. Here again, as in the case of the ammonium sulphate described above, the effect may have been exaggerated by the unfortunate year, nevertheless the residual value in the second year; must be considerable.

(In the 1918-19 series given in table 23 the addition of phosphate manures would seem to have given a negative result, but it appears certain that the unmanured plots were in some way better than the others.)

Superphosphate has apparently had no effect on the *paira* in the first year, the figures obtained by a comparison of all the plots showing a slight decrease; but similar figures for the second year show an increase from this manure of 16 per cent. of grain and 21 per cent. of straw in the *kerao*. In view of the warning already given (in the introduction) against too hasty a judgment of the effects of a manure on the *paira* crop I am inclined to think that the results must have been masked in some way the first year, even if it is equally likely that they have been somewhat exaggerated the second year.

The figures obtained by a comparison of the plots manured with potash with those not so manured show an average increase of 20 lb.

per acre of rice grain the first year, which is negligible, and a loss of 22 per cent. the second, which is of course only the compliment of the lucky gain made by the ammonium sulphate plots explained above, and is therefore of no consequence. It appears then that this manure has no effect on the rice in this soil.

Its influence on the *paira* crop is not definite. A comparison as above of all the plots of the first year shows an increase due to potash of 35 per cent. of grain and 29 per cent. of straw, but the residual results are *nil.*

TABLE XXIV.

(*Cuttack.*)

Number of		Total area in acres	Manure applied per acre	Average	
Trials	Years			Grain	Straw
6	3	1·2	160 lb. of sulphate of ammonia + 120 lb. of superphosphate + 100 lb. of muriate of potash.	2,273	4,600
6	3	1·2	160 lb. of sulphate of ammonia + 120 lb. of superphosphate.	2,286	4,757
6	3	1·2	160 lb. of sulphate of ammonia + 100 lb. of muriate of potash.	2,318	4,733
6	3	1·2	120 lb. of superphosphate + 100 lb. of muriate of potash.	1,946	3,321
6	3	1·2	Unmanured . .	1,782	3,145

None of these manures paid for their application in any of the three years, and the series was discontinued owing to the steady rise in their price. Nevertheless, while bearing this in mind, the results are of value in that they show the class of manures that will benefit the rice on this soil.

Ammonia is obviously beneficial. Comparing the 18 plots which received ammonium sulphate with the 12 which did not we arrive at an increase due to this manure of 23 per cent. of grain and 45 per cent. of straw.

Phosphatic manures gave a small increase, a comparison in the same way of the plots manured with superphosphate with those that were not showing an increase in the former of 6 per cent. of grain and 7 per cent. of straw.

Potash also gave an average increase of 7 per cent. each of grain and straw.

TABLE XXV.

(*Sabour.*)

Manure applied per acre	1913-14		1914-15		1915-16		1916-17	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Unmanured . . .	786	1,778	625	1,230	1,240	2,540	1,365	2,108
5 *maunds* (410 lb.) of bonemeal in 1913-14.	890	1,640	1,120	2,090	1,195	2,755	1,330	3,121
3 *maunds* (246 lb.) of bonemeal in 1913-14 and 1915-16.	685	1,460	1,190	2,402	870	1,525	1,665	2,455
1 *maund* (82 lb.) of bonemeal+½ *maund* (41 lb.) of saltpetre each year.	910	1,675	840	1,649	1,115	3,085	1,625	2,730

The experiments were in duplicate on 0·1 acre plots, the plots being the same each year ; the figures are the average of the two plots.

Deductions from this series must be somewhat indeterminate, particularly as all the manures have given a negative result in 1915-16, when it would seem that something must have happened to increase the relative yield of the unmanured plot.

The bonemeal and saltpetre has given an average increase of 118 lb. of grain per acre per annum during the four years.

It is noteworthy that in each case the addition of bonemeal has given a substantial increase, not in the year of its application but in the succeeding year. Thus the bonemeal applied in 1913-14 has given no definite results that year, the gain in one case being counterbalanced by the loss in the other, but in the next year the 5 *maunds* have produced an increase of 79 per cent. of grain over the unmanured plot, and the 3 *maunds* an increase of 90 per cent. Again the addition of 3 *maunds* in 1915-16 has produced no result in that year but has resulted in an increase of 22 per cent. of grain the next year.

The single application of 5 *maunds* of bonemeal in the first year has produced slightly more during the four years than have the two applications of 3 *maunds* each.

TABLE XXVI.

(*Sabour.*)

Manure applied per acre	1914-15		1915-16		1916-17		1917-18	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Green manure (*sannai*) each year.	1,120	1,919	1,947	6,570	935	6,072	665	5,547
Green manure (*sannai*)+5 maunds (410 lb.) of bonemeal each year.	1,080	2,007	2,390	6,620	1,050	6,320	1,075	6,480
Green manure (*sannai*) + 5 maunds (410 lb.) of bonemeal in 1915-16 and 1917-18.	785	1,543	1,982	6,048	822	6,690	505	6,840
Green manure (*sannai*) + 10 maunds (820 lb.) of bonemeal in 1915-16 and 1917-18.	995	2,030	1,980	5,915	620	6,780	635	6,962

The experiments were in duplicate on 0·05 acre plots, the plots being the same each year, the figures are the average of the two plots.

The results in this series are not definite.

Comparing the plots which received green manure and bonemeal each year with those that received green manure alone, it appears that the bonemeal had no effect the first year (the yields being practically the same) but produced an increase of 23 per cent. the next year, followed by increases of 12 per cent. and 62 per cent. in the two following years That is, the bonemeal acted as in the previous table.

In the next two cases, however, the effect of the bonemeal is by no means clear. In 1915-16 we may conclude that the green-manure caused the increase, as the outturns are the same as that of the plots manured with green manure alone, but the bonemeal seems to have had no effect in the next year either. It is possible that the whole series has been upset by an uneven growth of the *sannai*, always a danger when the results are dependent upon a green-manure as a constant factor.

TABLE XXVII.

(Bankipore.)

Number of		Total area in acres	Manure applied per acre	Rice			Gram			Year's profit
Trials	Years			Grain	Straw	Profit	Grain	Straw	Profit	
						Rs. A.			Rs. A.	Rs. A.
4	2	0·8	300 lb. of basic slag	1,501	2,254	18 13	421	361	16 1	34 14
4	2	0·8	1,640 lb. of lime	1,533	2,402	3 4	480	454	18 7	15 3
4	2	0·8	Unmanured	1,497	2,198	32 1	558	454	21 8	53 9

TABLE XXVIII.

(Sabour.)

Manure applied per acre	1914-15		1915-16		1916-17		1917-18		Average	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Green manure (*sannai*) + 820 lb. of lime .	1,165	2,400	2,315	7,785	820	5,745	840	5,885	1,285	5,454
Green manure (*sannai*)	1,120	1,919	1,947	6,570	935	6,072	665	5,547	1,167	5,027

The experiments were in duplicat on 0·05 acre plots, the same plots receiving the manure each year, the figures are the average of the two plots.

TABLE XXIX.

(Cuttack.)

Manure applied per acre	1913-14		
	Grain	Straw	Profit
			Rs. A.
350 lb. of basic slag	1,855	2,742	31 4
1,640 lb. of lime	1,722	2,691	34 14
Unmanured	1,495	2,511	42 0

The experiments were in duplicate on 0·2 acre plots, the figures are the average of the two plots.

TABLE XXX.

(Cuttack.)

Manure applied per acre	1913-14		
	Grain	Straw	Profit
			Rs. A.
200 lb. of basic slag	1,978	2,870	33 6
1640 lb. of lime	2,258	3,280	43 3
Unmanured	1,906	3,068	42 11

The experiments were on 0·2 acre plots on broadcast rice.

TABLE XXXI.

(Cuttack.)

Manure applied per acre	1912-13	
	Grain	Straw
Green manure + 246 lb. of lime	2,367	3,777
Green manure (*dhaincha*)	2,434	3,938

The experiments were on four *plots* of 0·2 acre each, the figures are the average of the four plots.

Table XXXII.

(*Cuttack.*)

Number of		Total area in acres	Manure applied per acre	Average	
Trials	Years			Grain	Straw
6	3	1·2	Green manure + 1,230 lb. of lime.	2,134	3,177
6	3	1·2	Green manure (*dhaincha*)	2,131	3,417

In the above trials lime gave a 2 per cent. addition of grain at Bankipore, where it did not pay for its application, and 10 per cent. at Sabour. Its action at Cuttack varied, it gave no increase in six trials, 2 per cent. in four trials, 15 per cent. in two trials and 18 per cent. in one ; but in only one case did it pay for its cost.

Lime, therefore, is not a profitable manure for Bankipore or Cuttack and, though it appears more likely to do good at Sabour, this is not yet certain for the comparison (table 28) was a green-manured with a green-manured and limed area, and, depending as it does upon the growth of a crop, green manure is not necessarily a constant factor.

2. Simple manures.

By simple manures are meant manures which the ryot can obtain without much difficulty.

TABLE XXXIII.

(Dumraon.)

Manure applied per acre	1908-09		1909-10		1910-11.		1911-12			1912-13		
	RICE		RICE		RICE		RICE			RICE		
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Profit	Grain	Straw	Profit
									Rs. A.			Rs. A.
50 *maunds* of cowdung .	2,624	4,920	2,972	9,020	2,613	6,713	2,665	4,715	41 8	1,906	3,044	24 14
100 *maunds* of cowdung	2,152	3,854	2,972	8,610	2,644	4,428	1,896	3,792	19 11	1,588	3,382	11 6
34 *maunds* of cowdung + 3·75 *maunds* of castor cake.	3,075	2,665	3,321	9,840	2,572	4,920	2,685	4,920	32 7	2,285	5,032	35 8
Green manure (*sannai*) .	2,378	4,715	2,603	9,020	2,142	3,587	1,640	2,972	15 5	1,168	2,480	9 1
Green manure (*dhaincha*)	2,050	3,936	2,788	10,250	2,972	5,863	2,337	5,330	31 4	1,127	2,562	6 12
3 *maunds* of bonemeal + 1 *maund* of saltpetre.	2,255	4,612	2,829	7,380	2,767	5,227	2,347	3,997	25 7	1,691	3,761	6 11
Unmanured . . .	1,845	2,542	1,742	5,330	1,640	3,772	1,271	2,306	10 8	789	1,804	0 9

Manure applied per acre	1912-13				1913-14						
	GRAM				RICE		GRAM				
	Grain	Straw	Profit	Year's profit	Grain	Straw	Profit	Grain	Straw	Profit	Year's profit
			Rs. A.	Rs. A.			Rs. A.			Rs. A.	Rs. A.
50 *maunds* of cowdung	887	1,209	26 14	51 12	1,886	4,869	48 15	656	594	21 0	69 15
100 *maunds* of cowdung	461	481	10 0	21 6	1,722	3,844	39 6	676	574	21 10	61 0
34 *maunds* of cowdung + 3·75 *maunds* of castor cake	615	635	15 11	51 3	2,132	4,397	51 4	451	410	13 0	4 4
Green manure (*sannai*) .	615	512	14 8	23 9	1,578	3,382	30 11	533	471	16 7	47 2
Green manure (*dhaincha*)	512	779	13 9	20 5	1,865	4,264	44 3	328	284	6 8	50 11
3 *maunds* of bonemeal + 1 *maund* of saltpetre.	471	594	11 1	17 12	1,322	2,972	8 8	348	225	8 3	16 11
Unmanured . .	287	348	3 8	4 1	1,250	2,665	24 9	154	123	1 3	25 12

Manure applied per acre.	1914-15.							1915-16.			
	RICE.			GRAM.				RICE.			GRAM.
	Grain.	Straw.	Profit.	Grain.	Straw.	Profit.	Year's profit.	Grain.	Straw.	Profit.	
			Rs. A.			Rs. A.	Rs. A.			Rs. A.	
50 *maunds* of cowdung	1,619	3,936	54 12	205	205	2 14	57 10	2,132	3,690	47 9	..
100 *maunds* of cowdung	1,650	3,116	50 7	154	154	0 6	50 13	1,998	3,484	38 12	..
34 *maunds* of cowdung + 3·75 *maunds* of castor cake.	2,081	3,403	58 10	102	123	1 15	56 11	2,095	3,740	38 4	Crop not worth harvesting.
Green manure (*sannai*) .	2,152	3,639	66 7	143	154	..	66 7	1,931	4,202	41 0	..
Green manure (*dhaincha*)	1,127	3,649	16 13	82	102	2 15	13 14	1,449	3,484	28 10	..
3 *maunds* of bonemeal + 1 *maund* of saltpetre	1,250	2,378	5 3	113	102	1 10	3 9	1,586	2,510	10 11	..
Unmanured . .	635	1,640	8 3	82	102	2 15	5 4	1,009	2,356	8 4	..

The experiments were on 0·2 acre plots, each plot receiving the same manure yearly.

This interesting series was started by my predecessor before the formation of the province. Unfortunately it could not be laid out in duplicate as there are not sufficient suitable rice plots at Dumraon. After a careful study of the plots (which I was better able to make after my transfer to Bankipore when this became my nearest outlying farm as opposed to his furthest from Calcutta), I found that the plot manured with 34 *maunds* of cowdung and 3·75 *maunds* of castor cake was lower, and therefore usually better, than the rest, which discounts to some extent the comparatively large yields from this manure. The plot manured with 50 *maunds* of cowdung was just lower than the others. Thus, as is generally the case with a single series, certain reservations are necessary when comparing the outturns plot with plot.

Nevertheless the accumulated benefit derived by applying these manures yearly and the profit that would accrue where such a practice common is most plain, and, if necessary, leaves a large margin for any error that might be due to variations in the plots. Thus if we omit the suspect plot manured with 34 *maunds* of cowdung and 3·75 of cake and, further, reduce the outturns from the plot manured with 50 *maunds* of cowdung to the same as those from the plot manured with 100 *maunds* (which would more or less agree with the experience on other farms, as is shown later), we find that had a man owning 5 acres of similar rice land manured each acre yearly with one of these five manures for eight years he would have increased his rice grain receipts by an additional 29,693 lb. Thus :—

From his acre manured with—	lb.
50 *maunds* of cowdung	6,441
100 *maunds* of cowdung	6,441
Sannai green manure	5,411
Dhaincha green manure	5,534
3 *maunds* bonemeal + 1 *maund* saltpetre	5,866
TOTAL	29,693

His extra receipts in money during the last five years alone, and only counting the rice, would have been, according to the farm accounts which naturally show less profit than a cultivator would make, Rs. 442. (As a matter of fact, they would have been more, for an Indian cultivator wise enough to apply such a series of manures would not only save over labour and incidental expenses, but would notice when his bone-meal and saltpetre plot was being run at a loss owing to the rise in price of these manures, and would have abandoned this dressing.)

But there is another way of examining the results which is not open to the same objections due to the series being on a single line of plots, that is a comparison of the relative returns of the plots. Whatever the initial difference between the outturn of the plots, any increase or decrease of this difference must be due to the treatment of the plot, and a steady advance must be due to the accumulated effect of the manure. In practice, of course, dealing with living plants and a complicated soil one cannot expect an arithmetical progression, but only an indication.

If the increase over the unmanured plot in the first year in each case is taken as 1 and the increase in the other years reduced proportionally, we get the following figures :—

TABLE XXXIV.

Manures per acre.	1908-9	1909-10	1910-11	1911-12	1912-13	1913-14	1914-15	1915-16
50 *maunds* of cowdung .	1	1·579	1·249	1·789	1·434	0·816	1·263	1·442
100 *maunds* of cowdung .	1	4·007	3·27	2·036	2·603	1·537	3·306	3·222
34 *maunds* of cowdung + 3·75 *maunds* of castor cake.	1	1·284	0·758	1·15	1·216	0·717	1·176	0·883
Green manure (*sannai*) .	1	1·615	0·942	0·692	0·711	0·615	2·846	1·73
Green manure (*dhaincha*) .	1	5·102	6·498	5·2	1·649	3	2·4	2·146
3 *maunds* of bonemeal +1 maund of saltpetre.	1	2·651	2·749	2·624	2·2	0·176	1·5	1·407

Several deductions can be made from this table. In the first place none of the manures has proved harmful after a number of years, all have given an increase over the unmanured plot in the first year, and added to this in most of the succeeding years. Had the accumulated effects been harmful, the figures would have shown a gradual or rapid decline. These particular manures are not likely to cause harm, but I mention the fact because I have occasionally heard the opinion expressed that continuous green-manuring causes a decrease. That the *dhaincha* (*Sesbania aculeata*) has not done this is obvious. At first sight the case for *sannai* (*Crotalaria juncea*) may not seem so certain but applying a green manure is not the same thing as adding a definite quantity of manurial matter. The amount is dependent upon the growth of the plants to be ploughed in and these, like all plants, will vary from season to season, and therefore the fall to less than the original increase during three years is only due to faulty growth of the crop. Were it due

to any harmful action of the manure it would not have been followed by a rise to nearly three times in the seventh and over one and a half times in the eighth year.

From an examination of table 34 up to and including the year 1912-13, where it is divided by a vertical line, it appears that both the plot manured with 100 *maunds* of cowdung and that manured with 3 *maunds* of bone-meal and 1 *maund* of saltpetre have reached a level. That is to say the accumulated effect in both these manures does not seem to be raising the outturn any further. This implies that in each case the quantity applied yearly could have been reduced in future without lowering the outturn had the series been carried on as before, but at this point I introduced a *paira* crop.

This *paira* crop raised questions which have not yet been solved though perhaps the solution can be indicated. The cultivators of the neighbourhood do not grow a *paira* on light soils of this nature as a rule, and the wisdom of this is shown in these experiments where though the unmanured plot gave a small return the first year this fell to little more than half in the second, less than a third in the third (when the outturn did not even pay the small expenses incurred) and failed entirely in the fourth year. This looks as if some essential plant food was lacking in the soil. It is not nitrogen, firstly because a leguminous crop like gram would certainly obtain enough of this element on a soil that supported rice, secondly because in that case the *paira* crop on the bonemeal and saltpetre plot would stand out from the rest. It could hardly be phosphorous, for then also the bonemeal plot should have beaten the others. Therefore it is probably potash, and this is further borne out by a comparison of the plots; the best returns on the whole in each year were obtained from the plots manured with farm-yard manure, which contains a certain amount of potash but did not supply enough. (In the fourth year when the *paira* was not harvested, there was probably enough on the cowdung plots to produce a small profit though, owing to a misunderstanding, this was discarded with the rest.

Now, if a good *paira* crop could be grown on these lands it would almost double the yearly returns, as shown in the introduction to this paper when discussing the *paira* at Bankipore, and it would seem as if this might be obtained, and the yield of rice increased as well, by a simple and cheap manurial dressing containing potash. Before it can be recommended definitely, however, trials should be made on the Dumraon Farm; I was unable to do so as I had to wait for suitable plots and left before these could be obtained.

TABLE XXXV.

Dumraon.

Manure applied per acre	1916-17		
	Grain	Straw	Profit
			Rs. A.
50 *maunds* of cowdung	1,742	2,435	20 10
Green manure (*dhaincha*)	1,886	2,502	22 4
5 *maunds* of castor cake	1,993	2,914	13 5
Unmanured	1,698	2,726	20 10

The experiments were carried out on 0·2 acre plots.

This series, though of little value by itself, shows nothing to contradict the deductions made above. *Dhaincha*, though it has not given the largest yield, has proved the most profitable. Castor cake which has produced the largest outturn, has not paid for itself.

TABLE XXXVI.

(Bankipore.)

NUMBER OF		Total area in acres	Manure applied per acre	AVERAGE INCREASE OVER THE UNMANURED PLOT						
				RICE			GRAM			
Trials	Years			Grain	Straw	Profit	Grain	Straw	Profit	Year's profit
						Rs. A.			Rs. A.	Rs. A.
4	2	0·8	100 *maunds* of cowdung	340	574	—0 12	70	17	4 8	3 12
4	2	0·8	50 *maunds* of cowdung	240	291	0 6	81	99	4 12	5 2
6	3	1·2	5 *maunds* of castor cake . . .	150	137	—11 3	—90	—85	—4 11	—15 14
2	1	0·4	5 *maunds* of mustard cake . . .	—45	—570	—13 14	..	..	..	..
14	5	3	2 *maunds* of *khari* salt	270	112	6 13	44	32	1 2	7 15
4	2	0·8	2 *maunds* of sulphate of magnesia . .	224	384	—7 10	—137	—126	—6 14	—14 8
8	4	1·8	Green manure (*dhaincha*) . . .	—25	—97	—3 1	18	12	1 9	—1 8
4	2	0·8	Green manure (*sannai*) . . .	163	154	1 5	18	23	1 1	2 6

TABLE XXXVII.

(Bankipore.)

Manure applied per acre in 1915-16	Residual results in 1916-17 of the manures applied in 1915-16		
	Grain	Straw	Profit
			Rs. a.
100 *maunds* of cowdung	2,050	3,842	61 7
50 *maunds of* cowdung	1,575	3,080	42 6
5 *maunds* of castor cake . . .	1,807	2,520	44 2
2 *maunds* of *khari* salt	2,315	3,847	66 3
2 *maunds* of sulphate of magnesia . .	2,062	2,317	55 6
Green manure (*dhaincha*) . . .	1,602	3,300	44 4
Green manure (*sannai*) . . .	1,737	3,465	48 3
Unmanured	1,605	3,280	44 5

The experiments were in duplicate on 0·2 acre plots, the figures are the average of the two plots.

The majority of the manures in table 36 have not yet been tried a sufficient number of times to insure certainty in any recommendations for this soil but nevertheless it is advisable to record the results partly because by the accumulation of such records the effects of the manures will become definitely known, and partly because even a few trials, provided they are given no more weight than they deserve, give an indication of the value of the manures.

Well-preserved farm-yard manure, as might be expected, has given an increase, a dressing of 100 *maunds* per acre showing a higher additional yield of rice than any other of the manures considered. This extra yield, however, has not paid the cost at farm rates of the manure (valued at 2 annas a maund) and of carting and spreading it though when the additional yield of the *paira* crop is included a profit is shown. Manuring with 50 *maunds* of cowdung resulted in less rice but a larger profit. But the residual value must also be considered. There are figures for one year only on the rice alone in table 37. Taking the average yields of four trials in two years from table 36 and combining them with the residual results of two of these trials in one year from table 37, we find that after three crops the additional profits per acre are, from 100 *maunds* of cowdung Rs. 20-14, from 50 *maunds* Rs. 3-3 or Rs. 17-11 in favour of the larger amount.

A further series was laid down to compare the value of 100 *maunds* of cowdung with 50 *maunds*, the results of which are shown in the following table.

TABLE XXXVIII.

(Bankipore.)

Manure applied per acre	1914-15						Year's profit	RESIDUAL RESULTS IN 1915-16						Year's profit
	RICE			GRAM				RICE			GRAM			
	Grain	Straw	Profit	Grain	Straw	Profit		Grain	Straw	Profit	Grain	Straw	Profit	
			Rs. A.			Rs. A.	Rs. A.			Rs A.			Rs. A.	Rs. A.
100 *maunds* of cowdung . .	1,659	4,710	45 3	1,014	1,150	56 10	101 13	1,737	3,075	44 14	877	552	34 0	78 14
50 *munnds* of cowdung . .	1,654	4,265	48 15	946	1,086	50 10	99 9	1,604	2,710	38 12	640	460	23 6	62 2

The experiments were in duplicate on 0·2 acre plots, the figures are the average of the two plots.

In this case the larger dressing proved as usual less profitable on the rice than the smaller in the first year but at the end of two years had given an extra yield per acre of 138 lb. of grain and 810 lb. of straw of rice with an increased profit of Rs. 2-6 and 305 lb. of grain and 156 lb. of straw of gram with an increased profit of Rs. 16-10, or a total additional profit of Rs. 19.

It may be concluded therefore, that when a single dressing is given at intervals it is better to apply 100 rather than 50 *maunds* of cowdung.

Returning to table 36 ; oil-seed cakes, though usually raising the yield, have not proved profitable manures at Bankipore.

Khari salt (hide salt) has given the highest average yield of rice grain of any of these manures except one, and the largest money return while its residual value is also considerable in the one year shown in table 37. Sulphur and chlorine are both deficient in this soil. Magnesium sulphate produces nearly as great an effect as *khari* salt, and the figures have been included for comparison, but its greater cost puts it out of the running as a rival. Common salt also increases the yield of rice, the addition of 2 *maunds* (164 lb.) per acre to broadcast rice in 1917-18 resulted in an increase of 229 lb. of grain, but the manure did not pay for itself. *Khari* salt is an impure sodium sulphate containing chloride and owing to its very impurities, provides both sulphur and chlorine at a lower cost in each case than if they were added separately.

Green-manuring with *sannai* has shown a profit. The negative results with *dhaincha* are surprising and contrary to the experience on other farms, but a reference to tables T and U in the appendix show that this manure gave a profit over the unmanured plots in three years out of the four and it is probable that there was some unrecorded adverse factor in the fourth. This view is strengthened by the fact that the average increase of the *paira* is the same for both the manures.

Table XXXIX.

(*Cuttack*).

Number of		Total area in acres	Manure applied per acre	Average increase over the unmanured plots		
Trials	Year			Grain	Straw	Profit
14	10	2·77	Green manure (*dhaincha*) .	327	495	Rs. A. 8 2
9	5	1·73	50 *maunds* of cowdung . .	166	112	2 3
7	4	1·4	50 *maunds* of village *khatto* .	34	4	—0 14
2	1	0·33	5 *maunds* of gingelly cake .	2	—192	—11 8

The profit of the green manure is based on ten trials only.

Green-manuring with *dhaincha* (*Sesbania aculeata*) has given the best results of the manures tried on the Cuttack Farm. The advantage of green-manuring is its low cost, and it is well worth recommending in the neighbourhood.

Fifty *maunds* of cowdung, although so far not producing so much increase in the yield of rice on this soil as at Bankipore, has proved a profitable manure.

The comparison of cowdung with an equal quantity of village *khatto* shown in this table emphasises two useful points. *Khatto* is a dry mixture of cowdung and ashes used as a manure by the local cultivators, and may be taken as their farm-yard manure. But farm-yard manure of the ordinary type preserved under cover on the farm is shown to be nearly five times as effective. Again the use of *khatto* resulted in a small loss on the farm (14 annas per acre) the slight extra yield not paying for the extra labour and cost of the manure. This helps to prove the contention several times repeated in this report that any manures which pay on the farms will pay the cultivators still more as his expenses are lower; for in this instance *khatto* manure must pay the cultivators or they would not apply it.

The trials of cake are too few for certainty in themselves, but here again this type of manure has not been found profitable.

TABLE XL.

(*Sabour.*)

Manure applied per acre	1912-13	
	Grain	Straw
Green manure (*dhaincha*)	1,687	3,276
Unmanured	1,499	3,227

The experiments were in triplicate in 0·1 acre plots, the figures are the average of the three plots.

Green-manuring with *dhaincha* has given an increase of 188 lb. per acre in this case, or 12·5 per cent.

D. Conclusions.

Various details of rice cultivation in Bihar have been examined in part B, and the results so far obtained appear to me to warrant the following conclusions.

It pays to plough those rice lands of Patna and Cuttack which are not at present cultivated during the hot weather, if a Punjab or some similar plough is used—and it would probably pay to do so elsewhere. (Section 1.)

Seed selection by the simple salt water method pays, and should be adopted by the cultivators. (Section 2.)

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Seed selection by the simple salt water method pays, and should be adopted by the cultivators. (Section 2.)

Transplanted rice produces more grain and pays better than broadcast rice. (Section 3.)

The method of cultivating broadcast rice in vogue in Orissa and Chota Nagpur, while probably in itself inferior to that of Bihar, is capable of a simple combination with green manure that has given an increase of 17 per cent. of grain. (Section 4.)

Sowings should take place as early as possible, as a delay results in a considerable loss that increases rapidly the longer the sowing is put off. (Section 5.)

A wet seed-bed pays better than a dry seed-bed. (Section 6.)

The usual seed rate is correct under present conditions. (Section 7).

The time the seedlings are kept in the seed-bed before transplantation is probably correct, at any rate it cannot be reduced. (Section 8.)

The number of seedlings transplanted in each bunch cannot with safety be reduced below eight in Bihar. (Section 9.)

The distance apart at which the seedlings are transplanted is probably correct, at any rate it cannot be increased. (Section 10.)

The results of three years' experiments support the contention that the authorities of the Sone Canals would be justified in insisting on different blocks of the canal-irrigated lands being nigarred on varying dates between September 1st and October 15th, as this would not lower the yield of rice and would enable the canal to supply a larger area. During these three years no harm has resulted through varying the *nigar* between these dates, and, while there is no harm in continuing the experiments up to the five to seven years I originally suggested, it is unlikely, from every point of view, that so small a variation in the time of *nigar* would cause a loss, certainly not one equal to the gain that would result from the larger crops, and greater insurance of crops, on the extra land that could be irrigated. (Section 11.)

The examination of manures in part C cannot be summarised so easily. The primary object of the experiments with chemical manures (section 1) is to ascertain what class of manure is required, and of those in section 2 to find cheap manures that will pay : naturally the enquiries overlap. The answer in each case depends chiefly upon the nature of the soil and varies from place to place ; general deductions, therefore, are not of much value.

Expensive chemical manures are not likely to pay under existing conditions on rice alone, although they may more than pay their way where a good *paira* crop can be grown in addition, as we have seen at Bankipore. A possible exception is ammonium sulphate for, as might be expected with a gramineous crop such as rice, this manure has given a large increase, 23 per cent. of grain at Cuttack and 33 per cent. at Bankipore. (The difference in favour of Bankipore is probably due to the sulphur in the manure, an element that is deficient on that farm.)

On the other hand special cases may occur where it will pay to import manures for a definite purpose; a case in point is Dumraon, and possibly Cuttack, where it seems likely that potash may enable a good *paira* to be grown and thus nearly double the proceeds from the land. (Introduction and part C, section 2, table 33.) The possibility of introducing a *paira* crop should be carefully considered on all rice lands on which it is not now grown.

Several local manures have been proved to pay..

Of these the most important under present conditions is green manure, because of its low cost and the ease with which it can be applied. Green-manure is obtained by sowing 30 lb. per acre of *dhaincha* (*Sesbania aculeata*) or 60 lb. of *sannai* (*Crotalaria juncea*) on the rice fields at the first rain and ploughing it in when the land is puddled before transplanting. The cultivator can grow the seed on any unused land, and its application only requires a little extra work, a rough ploughing or two at sowing time and one or two extra when puddling.

A reference to the tables shows that *dhaincha* gave an increase of 19·8 per cent. of grain and Rs. 8-2 per acre of profit at Cuttack, 11 per cent. of grain and Rs. 1-10 per acre of profit at Dumraon, 12 per cent, of grain at Sabour. The average result at Bankipore was a decrease. but the manure resulted in an increase of grain and profit in three out of the four years and was probably masked in the fourth by some unexplained error; more particularly as the average increase in the *paira* was the same as that from *sannai*. *Sannai* gave an increase of 14 per cent. of grain and Rs. 1-5 per acre of profit at Bankipore, the only farm on which it was tried. (I have not included table 33 at Dumraon, where both did well, as the series is single and accumulative.)

Well-preserved farm-yard manure is also profitable. The average increase at Bankipore from a dressing of 100 *maunds* was 29·2 per cent. of rice and 13·6 per cent. of *paira* grain. The addition of 50 maunds produced an increase of 20·6 per cent. of rice and 15·9 per cent. of *paira* grain at Bankipore, 8·8 per cent. of rice grain at Cuttack and 2·6 per cent. at Dumraon (again ignoring table 33). When a single application is made at intervals 100 *maunds* are more profitable than half that amount. Well-preserved farm-yard manure proved five times as valuable as the local substitute at Cuttack.

Khari salt is a profitable manure on soils, such as that at Bankipore which are deficient in sulphur and chlorine. It gave an average increase of 19 per cent. of rice grain, 9 per cent. of *paira* grain, and Rs. 7-15 per acre of profit. When tried at Cuttack, where the chemical analysis shows there is more sulphur, it did not pay for itself. (Table W in the appendix.)

APPENDIX

B.—CULTIVATION EXPERIMENTS.

(1) Hot weather cultivation.

TABLE A.

(*Bankipore.*)

Ploughed in the hot weather with a	1914-15		1915-16				1916-17			
	RICE		RICE.		GRAM		RICE		GRAM	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Punjab Plough . .	489	642	1,322	1,985	747	538	470	1,230	1,000	800
Hindustan Plough .	478	560	...	...	...	...	1,210	1,880	1,310	1,230
Local Plough . .	365	543	1,159	1,333	677	506	230	700	840	780
Unploughed . .	489	632	961	1,568	619	426	720	1,430	840	750

TABLE A—*contd.*

(*Bankipore.*)—contd.

Ploughed in the hot weather with a	1916-17				1917-18				1917-18			
	RICE		GRAM		RICE		GRAM		RICE		GRAM	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Punjab Plough . .	1,485	2,082	1,097	1,037	1,461	1,656	597	411	1,646	1,993	946	825
Hindustan Plough .	...	...	...	...	1,337	1,615	761	514	...	...	...	...
Local Plough . .	...	...	...	...	1,162	1,368	1,193	1,029	...	...	...	...
Unploughed . .	1,312	2,090	760	737	1,049	1,543	802	617	1,905	2,216	704	586

In 1914-15 each experiment was in triplicate on 0·2 acre plots, in 1915-16 on four 0·2 acre plots, in 1916-17 and 1917-18 the first series was on 0·1 acre plots, the second in duplicate on 0·2 acre plots. Where they were on more than one plot the figures are the average of the plots.

TABLE B.

(Cuttack.)

Treatment	1915-16		1916-17	
	Grain	Straw	Grain	Straw
Ploughed in the hot weather . .	1,353	1,706	1,086	2,060
Unploughed	1,107	1,537	1,025	1,291

Each year the experiments were in duplicate on 0·2 acre plots. The figures are the average of the two plots.

(2) Seed Selection.

TABLE C.

(Cuttack.)

Seed sown	1914-15		1915-16	
	Grain	Straw	Grain	Straw
Seed that did not pass through sieve .	1,871	2,870	1,638	2,296
Corresponding unselected seed . .	1,842	2,767	1,645	2,060
Seed that sank in a saturated salt solution.	1,826	2,829	2,196	2,234
Corresponding unselected seed . .	1,771	2,562	1,827	2,398

Each year the experiments were in duplicate on 0·2 acre plots, the figures are the average of the two plots.

(3) Transplanted and broadcast rice compared.

TABLE D.

(Cuttack.)

Cultivation	1915-16		1916-17		1917-18		1918-19	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Transplanted . .	1,927	2,362	1,491	1,588	1,571	2,255	1,189	1,845
Broadcast . . .	1,684	1,942	1,247	1,435	1,368	3,023	650	1,614

Each year the experiments were in duplicate on 0·2 acre plots, the figures are the average of the two plots.

(4) Broadcast rice in Orissa.

TABLE E.

(*Cuttack.*)

Seed rate per acre	1912-13		1913-14		1914-15		1914-15		1915-16		1916-17		1917-18.	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
40 *seers* (80 lb.) . . .	2,213	4,125	2,094	2,624	1,604	3,101	1,481	2,470	1,555	1,845	1,578	2,203	2,039	2,998
30 *seers* (60 lb.) . . .	2,554	4,258	2,149	2,709	1,174	1,994	1,317	2,255	1,524	1,538	1,720	2,562 / 2,229	2,234	2,665
20 *seers* (40 lb.) . . .	2,589	4,438	2,156	2,672	1,404	2,896	1,532	3,270	1,570	1,891	1,920		2,167	2,076

Each series was in duplicate on 0·2 acre plots ; the figures are the average of the two plots.

TABLE F.

(*Cuttack.*)

Seed rate per acre	After treatment	1914-15		1915-16	
		Grain	Straw	Grain	Straw
40 *seers* (80 lb.) .	Ploughed through	1,481	2,470	1,555	1,845
30 *seers* (60 lb.) .	Do. . .	1,317	2,255	1,524	1,538
20 *seers* (40 lb.) .	Do. . .	1,532	3,270	1,570	1,891
15 *seers* (30 lb.) .	Not ploughed .	1,783	3,198	1,491	2,357

Each year the experiments were in duplicate on 0·2 acre plots, the figures are the average of the two plots.

TABLE G.

(*Cuttack.*)

Treatment	1915-16			1916-17			1917-18		
	Grain	Straw	Profit	Grain	Straw	Profit	Grain	Straw	Profit
			R a.			*R a.*			*R a.*
Green manure (*dhaincha*)	2,328	3,088	50 3	1,214	1,740	17 3	1,589	2,614	18 8
Unmanured .	2,182	2,702	45 6	850	1,563	8 9	1,335	2,716	12 10

Each year the expriments were in duplicate on 0·2 acre plots, the figures are the average of the two plots.

(6) Wet and dry seed beds.

TABLE H.

Cultivation	SABOUR						CUTTACK					
	1913-14		1914-15		1916-17		1916-17		1917-18		1918-19	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain]	Straw
Wet seed-bed . .	2,260	..	762	..	205	497	1,711	3,162	1,835	3,357	1,788	2,947
Dry seed-bed .	2,160	..	686	..	295	1,030	1,701	3,049	1,507	3,229	1,732	2,588

At Sabour the first year each experiment was on 8 plots of 0·025 acre, and in the two following years on 4 plots of 0·025 acre ; at Cuttack each year the experiments were in duplicate on 0·2 acre plots ; in all cases the figures are the average of the plots.

(7) Seed rate in seed bed.

TABLE I.

(*Sabour.*)

Seed sown per acre of seed bed	1914-15	1915-16	1916-17
	Grain	Grain	Grain
2 *maunds* (164 lb.)	1,351	1,096	1,137
4 *maunds* (328 lb.)	1,359	1,058	1,061
10 *maunds* (820 lb.)	1,149	1,163	1,186

Each year the experiments were on 0·1 acre plots.

TABLE J.

(*Bankipore.*)

Seed sown per acre of seed bed	1914-15		1915-16		1916-17	
	Grain	Straw	Grain	Straw	Grain	Straw
5 *maunds* (410 lb.) .	815	981	887	1,244	499	713
7·5 *maunds* (615 lb.) .	697	946	541	1,107	635	848

Each experiment was on 6 plots of 0·2 acres in 1914-15 and on 3 plots of 0·25 acre in each of the two following years ; the figures are the averages of the plots.

TABLE K.

(*Cuttack.*)

Seed sown per acre of seed bed	1916-17		1917-18		1918-19	
	Grain	Straw	Grain	Straw	Grain	Straw
3 *maunds* (246 lb.) .	1,547	1,947	1,300	2,532	1,055	1,058
4 *maunds* (328 lb.) .	1,886	2,306	1,309	2,460	1,257	1,319
5 *maunds* (410 lb.) .	1,845	1,742	1,555	2,460	1,230	1,435

Each year the experiments were in triplicate on 0·2 acre plots ; the figures are the average of the three plots.

(9) The number of seedlings to transplant in each hole.

TABLE L.

(Bankipore.)

Number of seedlings	1912-13		1913-14		1914-15				1915-16			
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
1 in each hole . .	..	..	788	1,276	919	1,297	..	..	401	960	..	..
2 in each hole . .	1,126	2,371	1,005	1,325	785	1,102	734	912	365	854	574	1,092
4 in each hole . .	1,205	2,426	979	1,450	867	1,350	730	894	407	885	711	1,212
8 in each hole . .	1,316	2,668	1,150	1,799	1,081	1,830	805	1,085	574	1,167	859	1,222

Number of seedlings	1916-17				1917-18.		1918-19.	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
1 in each hole . .	..	..	..	..	..	..	..	..
2 in each hole . .	1,676	2,492	470	692	1,449	2,869	415	960
4 in each hole . .	1,829	2,589	644	742	1,539	3,152	505	985
8 in each hole . .	1,898	2,897	586	908	1,539	2,990	875	1,680

Each experiment was on 20 plots of 0·2 acre each in 1912-13 ; on 4 plots of 0·2 acre each in 1913-14 and 1914-15 (both series) ; on 2 plots of 0·25 acre each in 1915-16 (both series) ; the first series on three and the second on 2 plots of 0·25 acre each in 1916-17 ; on 3 plots of 0·25 acre each in 1917-18 ; on 2 plots of 0·2 acre each in 1918-19. The figures are the average of the various plots.

TABLE M.

(Cuttack.)

Number of seedlings	1912-13		1913-14		1914-15		1915-16		1916-17	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
1 in each hole . .	2,097	3,895	2,296	2,870	2,076	3,546	1,660	2,678	1,238	2,858
2 in each hole . .	2,189	4,147	2,852	2,716	1,932	3,290	1,545	2,644	1,300	2,985
4 in each hole . .	2,261	4,762	2,665	3,280	2,132	3,921	1,746	2,572	1,210	2,972
8 in each hole . .	2,132	4,946	2,465	3,408	2,199	4,095	1,727	3,080	1,040	2,998

Each year the experiments were in duplicate on 0·2 acre plots; the figures are the average of the two plots.

TABLE N.

(*Sabour.*)

Number of seedlings	1912-13		1913-14	1914-15		1915-16	1916-17	
	Grain	Straw	Grain	Grain	Grain	Straw	Grain	Straw
1 to 2 in each hole . .	2,005	4,261	2,601	992	976	2,776	1,028	2,091
4 to 6 in each hole . .	2,469	4,580	2,678	1,152	1,192	3,309	1,195	2,415

The first year the experiments were on single plots of 0·1 acre each, and in the following years on 40 plots of 0·025 acre each, the figures are the average of the 40 plots.

(10) The distance apart at which to transplant the seedlings.

TABLE O.

(*Sabour.*)

Distance apart	1914-15		1915-16		1916-17	
	Grain	Straw	Grain	Straw	Grain	Straw
6 inches . . .	1,252	...	1,615	4,787	1,470	3,537
9 inches . . .	912	...	1,160	4,200	1,485	2,990
12 inches . . .	667	...	877	3,282	1,212	2,255
18 inches . . .	142	...	660	2,605	560	1,645

Each year the experiments were on 0·05 acre plots.

(11) Nigar.

TABLE P.

Kind of rice	Treatment	SOHARA.								AGEON.							
		1916		1917		1918		1916		1917		1917		1918		1918	
		Grain.	Straw.	Grain.	Straw.	Grain.	Straw.	Grain.	Straw.	Grain.	Straw.	Grain.	Straw.	Grain.	Straw.	Grain.	
Main crop, harvested in December.	Nigarred at the usual time . .	1,570	1,578	1,761	3,053	1,912	2,273	1,365	2,269	662	1,377	1,956	1,912	664	1,266	1,482	1,871
	Not nigarred	1,306	1,399	1,672	2,437	1,860	1,897	1,358	2,286	808	1,770	1,804	2,383	734	1,192	1,441	1,847
	Nigarred at the usual time+ *khari* salt.	1,797	2,026	1,638	1,652	1,872	2,092	1,424	2,296	1,027	1,512	1,797	2,081	709	1,389	1,416	2,020
	Not nigarred+*khari* salt . .	1,463	1,505	1,748	2,753	1,994	2,019	1,556	2,432	1,058	1,815	1,610	2,147	1,426	1,992	1,298	1,980
	Nigarred at the usual time but not allowed to dry enough to crack the soil.	1,760	1,645	1,843	2,326	1,865	1,533	1,481	2,465	841	1,512	1,073	1,385	799	1,229	935	1,336
	Nigarred on September 1st . .	1,046	1,018	1,859	2,213	1,759	2,158	1,207	2.066	980	1,328	1,584	1,928	635	1,340	1,356	1,858
	Nigarred on September 15th . .	1,153	1,069	1,422	2,098	1,866	2,180	821	1,776	768	1,045	1,547	1,903	740	1,229	1,134	1,593
	Nigarred on October 1st . .	1,452	1,474	1,459	2,342	1,640	1,854	703	1,570	546	996	1,520	1,808	556	1,161	1,078	1,587
	Nigarred on October 15th . .	1,325	1,377	1,768	2,361	1,700	2,232	1,443	2,687	907	1,500	1,225	1,762	597	1,057	1,177	2,299
	Nigarred at any time the weather permits from September 1st to October 15th	1,301	1,302	1,598	2,294	1,867	2,178	1,501	2,459	861	1,697	1,141	1,507	826	1,241	1,102	1,502
	Nigarred at any time the weather permits from September 1st to October 15th but not allowed to dry enough to crack the soil.	1,512	1,447	1,667	3,101	1, 943	2,377	1,370	2,306	781	1,512	1,395	1,746	683	1,180	1,132	1,510
Kartika, harvested in November.	Nigarred at the usual time . .	1,746	1,676	1,950	2,095	1,610	2,113	..	..	854	1,476	..	..	607	860	..	..
	Not nigarred	1,500	1,438	1,809	2,497	2,094	2,452	..	..	603	1,476	..	..	698	977	..	..

Each series was in duplicate. The area of the plots varied slightly in each series, at Sohara they were about 0·22 of an acre, at Ageon in one series 0·08 of an acre and in the other from about 0·2 to and 0·3 of an acre. The figures are the average of the two plots and are calculated on the exact area of the respective plots.

C. MANURIAL EXPERIMENTS.

1. Chemical manures.

TABLE Q.

(*Cuttack.*)

Manure applied per acre	1914-15		1915-16		1916-17	
	Grain	Straw	Grain	Straw	Grain	Straw
160 lb. of sulphate of ammonia +120 lb. of superphosphate +100 lb. of muriate of potash.	2,406	6,662	2,577	3,193	1,837	3,946
160 lb. of sulphate of ammonia +120 lb. of superphosphate.	2,470	6,995	2,470	4,150	1,919	3,125
160 lb. of sulphate of ammonia +100 lb. of muriate of potash.	2,388	6,611	2,542	4,130	2,024	3,459
120 lb. of superphosphate+ 100 lb. of muriate of potash	1,999	4,546	2,031	2,649	1,809	2,767
Unmanured . . .	1,947	4,433	1,901	2,008	1,498	2,995

Each year the experiments were in duplicate on 0·2 acre plots, the figures are the average of the two plots.

TABLE R.

(Bankipore.)

Manure applied per acre	1914-15							1915-16						
	RICE			GRAM			Year's profit	RICE			GRAM			Year's profit
	Grain	Straw	Profit	Grain	Straw	Profit		Grain	Straw	Profit	Grain	Straw	Profit	
			ℛ a.			ℛ a.	ℛ a.			ℛ a.			ℛ a.	ℛ a.
300 lb. of basic slag . . .	1,558	2,285	29 2	345	323	15 12	44 14	1,444	2,224	8 8	497	400	16 7	24 15
1,640 lb. of lime . . .	1,403	2,096	22 6	424	338	16 1	38 7	1,664	2,709	—28 14	536	570	20 13	—8 1
Unmanured	1,501	2,106	37 15	400	300	15 11	53 10	1,494	2,291	26 4	717	609	27 6	33 10

Each year the experiments were in duplicate on 0·2 acre plots, the figures are the average of the two plots.

TABLE S.

(*Cuttack.*)

Manure applied per acre	1916-17		1917-18		1918-19	
	Grain	Straw	Grain	Straw	Grain	Straw
Green manure + 1,230 lb. of lime.	2,425	3,305	2,204	3,229	1,773	2,998
Green manure (*dhaincha*) .	2,395	3,408	2,239	3,280	1,760	3,562

Each year the experiments were in duplicate on 0·2 acre plots, the figures are the average of the two plots.

2. Simple Manures.

TABLE T.

(*Bankipore.*)

Manure applied per acre	1914-15							1915-16						
	RICE			GRAM			Year's profit	RICE			GRAM			Year's profit
	Grain	Straw	Profit	Grain	Straw	Profit		Grain	Straw	Profit	Grain	Straw	Profit	
			℞ a.			℞ a.	℞ a.			℞ a.			℞ a.	℞ a.
100 *maunds* of cowdung . .	1,274	2,172	20 5	438	504	20 6	40 11	1,730	2,850	19 2	718	505	29 0	48 2
50 *maunds* of cowdung . .	1,222	2,024	24 12	495	561	24 7	49 3	1,582	2,432	16 14	684	612	25 6	42 4
5 *maunds* of castor cake .	1,218	1,968	15 12	363	425	15 8	31 4	1,570	2,542	8 11	475	382	15 9	24 4
2 *maunds* of *khari* salt . .	1,187	2,203	27 9	280	307	9 13	37 6	1,673	2,543	26 8	433	379	14 0	40 8
Green manure (*dhaincha*) . .	1,139	1,973	26 0	568	582	27 12	53 12	1,550	2,306	23 2	686	614	26 11	49 13
Green manure (*sannai*) . .	1,187	1,993	26 11	532	641	25 5	52 0	1,464	2,190	16 15	520	381	17 4	34 3
Unmanured	933	1,717	20 1	379	439	16 11	36 12	1,391	2,158	20 14	638	537	23 11	44 9

Each year the experiments were in duplicate on 0·2 acre plots, the figures are the average of the two plots.

TABLE U.

(Bankipore.)

Manure applied per acre	1916-17.							1917-18.						
	RICE			GRAM			Year's profit	RICE			GRAM			Year's profit
	Grain	Straw	Profit	Grain	Straw	Profit		Grain	Straw	Profit	Grain	Straw	Profit	
			℞ a.			℞ a.	℞ a.			℞ a.			℞ a.	℞ a.
2 *maunds* of *khari* salt . .	2,436	3,000	60 13	484	400	14 1	74 14	1,830	2,828	31 5	550	507	16 0	47 5
Green manure (*dhaincha*) . .	2,144	2,768	52 1	508	428	15 2	67 3	1,486	2,898	26 13	507	455	13 15	40 12
Unmanured	1,980	2,370	49 10	538	440	16 1	65 11	2,032	3,968	46 12	600	576	18 11	65 7
2 *maunds* of *khari* salt . .	1,730	2,560	31 3	1,112	1,052	37 10	68 13	2,026	2,178	30 5	1,003	848	30 5	60 10
Unmanured	1,067	1,612	10 6	745	722	22 6	32 12	1,525	2,031	21 3	648	545	15 13	37 0

Each year the first three (those above the blank line) were in duplicate on 0·25 acre plots, the last two (those below the blank line) in duplicate on 0·2 acre plots, the figures are the average of the two plots.

TABLE V.

(*Bankipore.*)

Manure applied per acre	Grain	1918-19	
		Straw	Profit
			₹ a.
5 *maunds* of mustard cake . . .	1,285	2,395	37 13
5 *maunds* of castor cake	1,315	2,765	34 9
55 *maunds* of cowdung	1,155	2,215	31 4
2 *maunds* of *khari* salt	1,335	2,480	64 15
Unmanured	1,330	2,965	51 11

The experiments were in duplicate on 0·2 acre plots, the figures are the average of the two plots.

TABLE W.

(Cuttack.)

Manure applied per acre	1907-08		1908-09		1909-10		1910-11		1911-12		
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Profit
											₹ a.
Unmanured	1,845	5,002	2,460	5,371	1,558	4,715	1,824	3,362	2,398	4,602	64 3
Green manure (*dhaincha*)	2,378	5,166	2,911	5,801	2,132	5,022	2,419	4,305	2,542	5,504	68 15
50 *maunds* of cowdung	..	..	..	..	..	..	..	..	2,439	4,940	62 6
50 *maunds* of village *khatto*	..	..	..	..	..	..	..	..	2,429	5,053	64 1
5 *maunds* of gingelly cake	..	..	..	..	..	..	..	..	..	..	..
100 *maunds* of cowdung	..	..	..	..	..	..	..	..	..	..	..
3 *maunds* of *khari* salt	..	..	..	..	..	..	..	..	..	..	..

Manure applied per acre	1912-13			1913-14			1913-14			1913-14		
	Grain	Straw	Profit	Grain	Straw	Profit	Grain	Straw	Profit	Grain	Straw	Profit
			₹ a.			₹ a.			₹ a.			₹ a.
Unmanured	2,517	3,782	58 12	1,445	1,907	30 7	1,906	3,068	42 11	1,495	2,511	42 0
Green manure (*dhaincha*)	2,434	3,938	56 0	1,784	2,091	38 11	..	..	..	..	..	..
50 *maunds* of cowdung	2,690	3,870	60 15	1,464	1,907	26 10	2,260	2,808	46 11	..	..	..
50 *maunds* of village *khatto*	2,373	3,354	51 13	..	..	..	..	..	..	..	..	..
5 *maunds* of gingelly cake	..	..	..	1,451	1,722	19 7	1,876	2,870	30 11	..	..	..
100 *maunds* of cowdung	..	..	..	..	..	..	2,122	3,177	43 2	..	..	..
3 *maunds* of *khari* salt	..	..	..	..	..	..	..	..	..	1,702	3,023	35 3

TABLE W.—*concld.*

(*Cuttack*)—concld.

Manure applied per acre	1915-16			1916-17			1917-18		
	Grain	Straw	Profit	Grain	Straw	Profit	Grain	Straw	Profit
			℞ a.			℞ a.			℞ a.
Unmanured	1,505	2,229	48 4	1,368	2,808	43 5	1,492	2,306	39 6
Green manure (*dhaincha*)	1,957	2,721	65 6	1,563	3,063	47 1	1,896	3,382	55 5
50 *maunds* of cowdung	1,763	2,654	56 5	1,470	2,716	43 6	..	..	..
50 *maunds* of village *khatto*	1,698	2,562	54 5	1,424	2,690	41 4	..	..	..
5 *maunds* of gingelly cake	..	..	..	..	..	..	..	..	..
100 *maunds* of cowdung	..	..	..	..	..	..	..	..	..
3 *maunds* of *khari* salt	..	..	..	..	..	..	..	..	..

From 1907-08 to 1911-12 inclusive the experiments were on 0·2 acre plots, the first two series of 1913-14 were on 0·16 acre plots, all the remainder were in duplicate on 0·2 acre plots, the figures in these cases being the average of the two plots. The second series in 1913-14 were on broadcast rice, the others as usual on transplanted rice.

MADRAS PRESIDENCY.

AREA UNDER.
ITALIAN MILLET.(SETARIA ITALICA).
TENAI.(TAMIL)
KORRA.(TELUGU)

DISTRICTS	A
GANJAM	
VIZAGAPATAM	
GODAVARI	
KISTNA	
GUNTUR	
KURNOOL	
BELLARY	
ANANTAPUR	
CUDDAPAH	
NELLORE	
CHINGLEPUT	
SOUTH ARCOT	
CHITTOOR	
NORTH ARCOT	
SALEM	
COIMBATORE	
TRICHINOPOLY	
TANJORE	
MADURA	
RAMNAD	
TINNEVELLY	
MALABAR	
SOUTH KANARA	
THE NILGIRIS	
TOTAL:	1.

Ustilago Crameri Koern. on *Setaria italica* Beauv.

[*Received for publication on 18th March, 1920.*]

Setaria italica is grown in all the districts of the Madras Presidency except Malabar and South Kanara. It is called 'Tenai' in Tamil and 'Korra' in Telugu. The total area of this crop in 1918 was 1,529,187 acres. The northern central districts of Cuddappah, Kurnool, Bellary, Anantapur and Guntur among themselves accounted for an area of 1,368,575 acres which is nearly 90 per cent of the total. Most other districts raise this crop to a greater or less extent wherever rain conditions permit. The importance of the crop as a food is well known. The map shows the extent of its cultivation in the several districts. It is grown as a pure crop in limited areas, but is generally grown mixed, the chief crop associated with it being cotton. In fact, this has given a name to the mixture which is known as "Korrapatthi" in the Ceded Districts.

Setaria italica is subject to the attack of some fungus diseases which cause much damage, the most important being *Sclerospora graminicola* Schroet (green-ear disease), *Uromyces Setaria italicæ* Diet. (rust) and *Ustilago Crameri* Koern. (smut). In the flowering stage the green-ear disease fungus causes proliferation of all parts of the flower so that the earhead becomes a mass of leafy shoots. The rust fungus produces brown spots on the leaves. The one that causes by far the greatest loss, however, is smut which converts the valuable food stored as starch in the seeds into a mass of black powder.

Symptoms. Outwardly the grains are the only parts that appear infected. The smutted grains are only very slightly larger than healthy ones. In the early stages when the healthy grains are still green, the smutted ones have become grey, while at a later stage the former become yellow, while the latter are brown. When the membrane of the smutted grain bursts (Pl. I, figs. 1 and 2), the black spores are liberated and give the grain and the glumes a dark dusky appearance, readily seen and much dreaded in certain tracts, where the cultivators aptly call it *katika korra* or sooty millet, though when pressed between the fingers, the

spore mass is not jet black but slightly brown. The spores are formed only in the spikelets. Sometimes all the shoots of the plant are affected and almost all the grains in the ear may be attacked. In some cases the upper spikelets may be free. In a partially attacked earhead the tip may be sound but the base is always affected. In no case has the upper portion of the earhead been found diseased, while the lower was sound. This gives an indication that infection proceeds from the bottom upwards and that when the inflorescence began to elongate the fungus did not keep pace with the development of the inflorescence and did not reach the uppermost part of the panicle.

Origin. In Siruguppa Taluk of Bellary District the disease was very severe in 1917, and a report by the Agricultural Demonstrator there led to the investigation of this subject. The grains of ten smutted earheads sent to the Laboratory were counted with a view to find out the proportion of healthy to smutted grains. There were 2,261 healthy grains and 9,005 smutted grains. The proportion of healthy to smutted grains was 1 to 4. Details are given below :—

No.	Healthy grains	Smutted grains
1	115	314
2	123	580
3	237	678
4	488	1,232
5	34	789
6	89	892
7	587	1,352
8	25	684
9	58	589
10	525	1,895
TOTAL	2,261	9,005

Loss. The area under Italian millet in Siruguppa Taluk in 1918 was 23,800 acres. The estimated loss because of smut was more than a quarter of the crop : but if it be taken at a quarter of the crop and

the average yield at 1,000 lb. per acre, then the total loss for the Taluk would be 250 lb. per acre, which at the price current at the time amounts to a money value of 11,90,000 rupees. The area under this crop in Siruguppa Taluk is only one-sixtieth of the total area of the Presidency, and though the smut was not so severe in most other tracts still it was present to some extent in all and this gives an idea of the great loss caused by this smut in one year. It thus became important that a method of treatment suitable to the means and capabilities of the ryot should be devised and demonstrated in those tracts where smut was severe and recurring.

Spores. In bulk the spore masses are black but when in a thin layer they look dull brown. They are aggregated into spore-balls (Pl. I, fig. 3) which readily disintegrate under a cover slip into the component spores. In shape they are globular to ovoid, and some show irregular indentations (Pl. I, fig. 3). They are smooth and their contents appear more or less granular. They measure $7{\cdot}7—11{\cdot}1 \times 5{\cdot}3—8{\cdot}2\mu$.

When placed in water, the spores begin to germinate usually in 6 to 9 hours. A germ tube is produced and the protoplasm contained in the spore passes into the tube (Pl. I, fig. 4). The rupture of the wall of the spore is so pronounced that the projecting portions of the spore-wall are seen along each side of the base of the germ-tube. It becomes divided by three or four septa (Pl. I, fig. 4). From each of the cells small buds arise near the septum and form sporidia. These, when detached, may either put forth a germ tube or two adjacent sporidia may become connected by a transverse branch. There are instances where the promycelium may not develop sporidia but becomes an ordinary hypha and penetrates the tissue of the host plants by its pointed extremity. Again a kind of fusion takes place by means of a tube from one segment of the same promycelium. Thus the upper segment becomes connected with the lower segment of the same promycelium by means of a curved tube which Brefeld[1] calls a "buckle-joint" or "knee-joint" (Pl. I, fig. 4, a, b, c). This is common when spores are germinated in water. But when germinated in sugar solution, these fusions do not occur, but the sporidia multiply in the manner of budding of "Yeast," thus giving rise to copious sporidial formation. This goes on until all the nutritive medium is exhausted. The course of infection is as follows :—

Penetration. The germ tube penetrates the wall of an epidermal cell and grows through the cells beneath the surface layer (Fig. 5). In

1 Brefeld. *Untersuchungen aus dem Gesamtgebiete, etc., der Mykologie,* Vol. V, 1883, pages 101 to 102.

Germination of the spores of this smut has been dealt with in detail.

the early stage of the seedling the hyphæ in sections of the nodes, are very numerous and very clearly seen. A month after the infection, hyphæ are only seen in the nodes (and near the apex of the shoot) (Pl. II). The fungus is found in masses. Perhaps this is due to the fungus not being able to keep pace with the rapid growth of the plant and the fungus gets torn up and isolated into fragments. Infection takes place when the seed begins to germinate and penetration has been seen only through the epidermal cells of the hypocotyl. The young mycelium grows inside along with the seedling, showing no external signs of its presence until the earheads are produced, when it forms its spores in the ovary.

Prevention—local. The seriousness of this disease and the necessity for its prevention are not unknown to the ryot of the Ceded Districts, only the steps taken are primitive. He thinks that a mixture of cattle-urine, garlic, asafœtida, sweet-flag, is effective, but this has been on various trials found to be ineffective. Various preventive measures[1] are used against this and similar smuts on cereals in other parts of the world as washing the grains in water, steeping the grain in copper sulphate solution or in formalin or in hot water or exposing it to hot air. Copper sulphate is known to the ryots and is available in the local bazaar. It is the cheapest, safest and most acceptable method so far as he is concerned and hence it is recommended. Formalin, though as effective as copper sulphate, is difficult to handle except under skilled supervision. The hot water, and the hot air methods, however, are not suitable to the ordinary cultivator, as he has no knowledge of the meaning or use of a thermometer. The limits of safety were considered too narrow for the satisfactory adoption of this method.

Other references.

1. G. P. Clinton in "North American Ustilagineæ" has described this smut on the Italian millet as *Ustilago Crameri* Koern. His description is "Sori in the spikelets, infecting all of the spike, ovate, about 2-4 mm. in length, chiefly destroying inner and basal parts; spores reddish-brown, chiefly ovoid to subspherical though occasionally more elongated and irregular with usually pitted contents, chiefly 8-11μ in length.

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[1] Hecke, L. Vorversuche zur Bekampfung des Brandes der Kolbenhirse. *Zeits. Landw. Ver. Oesterr.*, 1902, 933, 1902.

(Gives results of treatment with hot water, formalin, corrosive sublimate, and copper sulphate on germination of *Ustilago Crameri* and *U. Panici-miliacei.*)

Stuart, W. Formalin as a Preventive of Millet Smut. *Ann. Rep. Ind. Agr. Exp. St.*, 13, 25, 1901, shows from experiment that seed soaked 1-4 hrs. in formalin, rate of 1 lb. to 45 gals. of water, was effective in preventing this smut.

"This fungus sometimes causes damage to the cultivated millets. It has been reported only during recent years from this continent. The ordinary hot water method of seed treatment is a preventive."

2. Brefeld. *Untersuchungen aus dem Gesamtgebiete, etc., der Mykologie*, Vol. V, 1883, pages 101 to 102.

Germination of the spores of this smut has been dealt with in detail.

3. Hecke, L. Vorversuche zur Bekampfung des Brandes der Kolbenhirse. *Zeits. Landw. Ver. Oesterr.*, 1902, 933, 1902.

(Gives results of treatment with hot water, formalin, corrosive sublimate, and copper sulphate on germination of *Ustilago Crameri* and *U. Panici-miliacei.*)

4. Stuart, W. Formalin as a Preventive of Millet Smut. *Ann. Rep. Ind. Agr. Exp. St.*, 13, 25, 1901, shows from experiment that seed soaked 1-4 hrs. in formalin, rate of 1 lb. to 45 gals. of water, was effective in preventing this smut.

5. Butler, E. J. "Fungi and disease in plants," pages 234-235.

As is the case with *Cintractia Sorghi Vulgaris* on *Andropogon Sorghum* (Short smut on cholum *Tamil* and jonna *Telugu*), another smut known to the cultivator and whose method of prevention is gradually being adopted by them, the smut on Italian millet, also yields readily to preventive treatment. The method of infection in both cases is the same. As in *Sorghum*, the smut on Italian millet adheres to the surface of the seed, germinates along with the seeds and enters into the young seedling only during the seedling stage.

Preventive experiments. In the investigation of this preventive method, the points to be settled were :—

1. the concentration of copper sulphate solution which would undoubtedly prevent the germination of the spores,
2. whether that concentration of the solution would at all affect the germination of the seed, and
3. whether the results obtained by 1 and 2 were confirmed by field trials.

1. *The effect of copper sulphate solution on the spores.* A few smutted grains were broken up and a small quantity of spores collected and made into ten lots for treatment. Each lot was put in a test tube. A few spores from each lot were placed on slides in distilled water to germinate. In 24 hours almost every spore had germinated in all the eleven lots.

The tubes with the spores were thoroughly shaken several times during the period in which they were in solution and then left to settle. The fluid in each tube was removed with a pipette and distilled water

put in. The tubes were again well shaken. When the spores again settled down the water was taken off and the tube refilled with water. This rinsing was repeated a number of times until the last rinsing water contained no trace of copper sulphate. As a further test, the last rinsing water from each tube was poured into a tube containing spores and left for the corresponding period of time. In no case did this steeping in this rinsing water affect the germination of the spores. The details of the experiment are given in the tabular form.

Test tube No.	Concentration of copper sulphate solution used	Time soaked	Period taken for testing germination	Results
1	...	12 hours	12 hours	In distilled water 50 per cent germination in 6 hours, 95 per cent in 12 hours, and 100 per cent in 24 hours.
2	0·1 per cent	15 minutes	120 hours	About 50 per cent germinated in 24 hours. The germ tube of spores that germinated lengthened and even this stopped after 96 hours.
3	0·1 „	30 „	Do.	No germination.
4	0·5 „	15 „	Do.	Do.
5	0·5 „	30 „	Do.	Do.
6	1·0 „	15 „	Do.	Do.
7	1·0 „	30 „	Do.	Do.
8	2·0 „	15 „	Do.	Do.
9	2·0 „	30 „	Do.	Do.
10	5·0 „	15 „	Do.	Do.

Note.—6 slides with drops of distilled water were used for germinating the spores in each case.

From these experiments it is seen :

(1) that the spores germinated in distilled water to the extent of 50 per cent in 6 hours and freely in twelve hours ;

(2) that 0·1 per cent solution of copper sulphate for 15 minutes retarded germination and hindered growth : the promycelium was short and did not produce sporidia during the period of observation ;

(3) that 0·1 per cent for 30 minutes stopped germination entirely as did all higher concentrations for periods of 15 and 30 minutes.

Under the conditions of the experiment, in working with small quantities of spores it is likely that the spore masses will be broken into their component parts to a greater extent than they will be in a field experiment where the seed is steeped in a copper sulphate solution. It may be anticipated that the spores may not be so well separated from each other and that the copper sulphate solution may thus not get at every individual spore, with the result that the same effect may not be produced in the field with any one concentration as is shown in the table of results.

2. *The effect of copper sulphate solution on the germination of the seeds.* In each experiment 100 seeds were placed in moist sterile sand. The sand was sterilized by being kept in hot-air sterilizer at 170 degrees centigrade for half an hour. In 48 hours all the 100 seeds germinated, showing thereby that the seeds were in a very good condition. With the seeds thus tested the following 15 series of experiments were tried with the results tabulated below :—

Serial No.	Strength of copper sulphate solution	Time steeped	Percentage of germination	Number of hours taken for germination
1	Untreated seed	...	100	48
2	0·5 per cent	15 minutes	99	96
3	0·5 ,,	30 ,,	100	120
4	1 ,,	15 ,,	98	Do.
5	1 ,,	30 ,,	99	Do.
6	2 ,,	15 ,,	99	Do.
7	2 ,,	30 ,,	99	Do.
8	2 ,,	10 hours	99	192
9	5 ,,	15 minutes	95	Do.
10	5 ,,	30 ,,	92	Do.
11	10 ,,	15 ,,	79	Do.
12	10 ,,	30 ,,	84	216
13	15 ,,	15 ,,	63	Do.
14	15 ,,	30 ,,	69	Do.

The experiment shows that the lower concentrations have no effect on germination, that the lowest concentration that has a definite effect is 5 per cent and that after steeping for 30 minutes, and that, above that

concentration, the germination is lowered in proportion as the concentration is greater. It is thus obvious that 5 per cent concentration of copper sulphate solution is the limit within which we can safely steep seeds. However, smut spores fail to germinate with even 0·5 per cent copper sulphate solution for 15 or 30 minutes. As a working formula, therefore, the strength of solution which is required to kill the spores and at the same time not affect the germination of the seed may be taken at somewhere about 2 per cent and the ordinary length of time may be half an hour. This allows a large limit for possible errors both in making the solution in the rough way in which a cultivator does it and in the time of steeping and still ensures success to the treatment.

Test as to whether the results obtained by (1) and (2) are confirmed by making a trial on a field scale. Seed was obtained from the stores at the Central Farm, Coimbatore. In order to get clean seed for this experiment it was steeped in 2·5 per cent formalin (*i.e.*, Schering's formalin diluted) for 15 minutes. That this treatment completely destroys the spores but does not hinder the germination of the seed was proved by repeated experiments. 32 plots were laid out in the compound of the Pot-Culture house of the Government Mycologist and were sown with seeds treated in the manner detailed below :—

1. Seed as obtained from the Central Farm stores without any treatment k. 1.
2. Seed soaked in 2·5 per cent formalin solution for 15 minutes k. 2.
3. Part of k. 2 was mixed with spores of *tenai* smut and this is k. 3.
4. Part of k. 3 was treated with copper sulphate solution as detailed below :—

Series	Strength of copper sulphate solution	Time of soaking
4	0·5 per cent	15 minutes (k. 4)
5	0·5 ,,	30 ,, (k. 5)
6	1 ,,	15 ,, (k. 6)
7	1 ,,	30 ,, (k. 7)
8	2 ,,	15 ,, (k. 8)
9	2 ,,	30 ,, (k. 9)
10	2 ,,	10 hours (k. 10)
11	5 ,,	15 minutes (k. 11)
12	5 ,,	30 ,, (k. 12)
13	10 ,,	15 ,, (k. 13)
14	10 ,,	30 ,, (k. 14)
15	15 ,,	15 ,, (k. 15)
16	15 ,,	30 ,, (k. 16)

Duplicate plots were laid out in each case, the seeds were sown on 20th November, 1918, and harvested on 13th February, 1919. The

plots that were sown with seed infected with smut, *i.e.*, (k. 3), showed 208 smutted (earheads) plants out of 350 that grew. All the other plots were entirely free from smut.

Thirty-two plots of one-cent each were laid out in field No. $2c_2$ in the Government Agricultural Station, Hagari, with the kind co-operation of Mr. Hilson, Deputy Director of Agriculture, Circles II and III. The seeds were sown on 23rd September, 1918. The plots were harvested in January, 1919. Only the artificially infected plot produced smutted earheads. The germination in all the plots was for some reason very uneven and the experiment is taken only qualitatively.

The following experiments were made to determine the place in the *tenai* plant through which the smut gains entrance. *Tenai* seed obtained from the Agricultural Demonstrator, Bellary, was disinfected with 2·5 per cent formalin for 15 minutes, dried, smeared with spores of the smut, and sown in pots with sterilized soil on the 17th December, 1917. Another lot of seeds was also sown at the same time, but these were disinfected with formalin but not smeared with smut spores. The pots used were new and were immersed in a 0·1 per cent solution of corrosive sublimate and dried. The soil that was put in the pot was kept in small lots in a hot-air sterilizer at a temperature of 170 degrees centigrade for half an hour. These pots were watered with sterilized water till the seeds came up to a seedling stage. When seeds germinated, some of them were carefully removed from the pots and examined under the microscope. But spores were seen to have germinated and to have produced lots of sporidia in two days. The germ tubes from the germinating spores were seen on the surface of the seed-coat and on the epidermal layer of the plumule and of the hypocotyl. The course of infection is as follows. The germ-tube penetrated the wall of the epidermal cell of the hypocotyl (Pl. I, fig. 5) and grew through the cells beneath the surface layer. In the early stages of the seedling, hyphæ are seen to be very numerous in sections of internodes and nodes. A month after infection, however, the hyphæ were only seen in the nodes, in the form of masses. Infection takes place when the seeds begin to germinate and the young mycelium grows along with the seedling showing no external signs of its presence until the flowers are produced, when it again forms its spores in the ovary. The seedlings grew up under sterile conditions in the pots for about a month. When they had grown sufficiently high they were transplanted into big pots. The soil used to fill up the pots was obtained from the Central Farm, Coimbatore. Sections from the nodes and internodes of some seedlings showed thick nodulose hyphæ, Pl. II. Out of 100 plants in the pots 95 showed smutted earheads. In the 100 plants grown out of seeds

that were not smeared with smut, no smutted earhead was seen. In a field in the Central Farm Coimbatore, sown on the 17th November, 1917, and harvested on the 5th February, 1918, out of 300 plants that grew from seeds smeared with smut spores, 165 plants showed smutted earheads. In the 300 plants that grew from seeds not smeared with smut spores, not a single plant was smutted.

To determine if the spores of the smut infect flowers of Italian millet and produce smut on the ears, the following experiment was laid out.

Tenai seed was disinfected with 2·5 per cent formalin for 15 minutes, dried, and sown in pots. The pots were new and dipped in 1 to 1,000 parts of corrosive sublimate solution and the soil sterilized by being kept in a hot-air sterilizer at 170 degrees centigrade for half an hour. The experiment was divided into two series with 20 plants in each series. When the plants grew up and were in shot-blade, the tops of these 40 plants were covered over with paper bags. As soon as the earheads came out of sheathing leaf, the stigmas of the flowers were dusted with smut spores in the following way. Dry spores of the smut were placed in a paper bag and shaken on to the flowers by inverting the bag over the earhead and shaking thoroughly. Sometimes the spores were placed with a camel hair brush. Examination of the dusted earheads with a hand-lens showed spores on the stigmas of flowers. The other set of 20 plants that were bagged, were not interfered with in any way, *i.e.*, they were not dusted with spores. After the earheads matured, the paper bags were removed and none of the earheads in either of the two sets were found to be smutted. This was repeated three times. It is thus seen that the spores of the smut are not capable of infecting the flowers of the plant. It may sometimes be suggested that the spores may lie dormant in the soil for one season and affect the later crop. This is against the life-history of the smut as the spore germinates quickly in water in a short time and the field is likely to have received a shower or two in the fallow period.

From the foregoing experiments the limits for copper sulphate solution both with regard to the fungus and the seed have been determined to be 0·5 per cent and 5 per cent, and 2 per cent has been shown as a good working concentration. The formula is easily translated into the measures understood by the ordinary cultivator. A kerosene bottle ordinarily available in the bazaar can be taken as a measure for water, and a rupee as the weight for the copper sulphate. To secure 2 per cent strength of solution he has to dissolve a rupee weight of copper sulphate in a bottle of water. The cultivator has thus to remember only two things, *i.e.*, one rupee weight of copper sulphate and a kerosene oil bottle of water. Steeping in 2 per cent solution for 10 minutes has been re-

commended in Bombay. But the bulk of the ryot population have yet to become familiar with the means of gauging accurately sub-divisions of an hour. The ryot has a rough and ready method of determining the time. Generally he keeps no clock or time-piece. He is guided mostly by the shadow cast by an object and he is always very nearly correct. He has inherited this method from time immemorial and it has not failed him : and a method he would understand better is to be perferred. Half an hour is easily understandable, a better unit which leaves a sufficient margin of safety.

The Deputy Director of Agriculture of Circles II and III conducted field trials with seed treated with 2 per cent copper sulphate solution. This was done consecutively for three years. A definite set of instructions was prepared for guidance and Agricultural Demonstrators visited villages several times before and after sowing. They showed the people how to prepare the solution and how to treat the seed in solution. In some plots treatment of seed and sowing were done under their personal supervision, while, in the majority of cases, the ryots did this part of the work closely following their instructions. During the several inspections of the treated plots by the Agricultural Demonstrators it was found that the treated plots presented no appearance of smut. This was the case not in one or two plots, but in hundreds of plots. One may realize the efficacy of this treatment, when one realizes that in 1917 ryots, usually extremely conservative, had grown 9,312 acres in Bellary District alone with treated seed. At the same time, it is necessary that only good seeds should be used as old grain may be injured by the treatment. The seeds should be dried quickly or sprouting may result. Sowing should be done soon after treatment.

SUMMARY.

(1) Smut causes great loss in *Setaria italica* (Italian millet) in certain districts of the Madras Presidency.

(2) The spores germinate freely in distilled water to as high a percentage as 95 in twelve hours ; but fail to germinate when placed in solutions of copper sulphate of 0·5 per cent and higher concentration for 15 to 30 minutes.

(3) That steeping seed of *Setaria italica* in solutions of copper sulphate of 5 per cent concentration for 30 minutes and higher concentration for 15 to 30 minutes reduces germination.

(4) That the smut enters the plant in the young seedling stage.

(5) That the spores do not infect the flowers.

(6) That to secure safety from infection, seed should be steeped in a 2 per cent solution of copper sulphate for 30 minutes.

EXPLANATION OF PLATE I.

Fig. 1. Earhead of *Setaria italica*, Italian millet, with smutted grains.

„ 2. Smutted grains enlarged.

„ 3 Spores of *Ustilago Crameri* Koern. × 400 and × 800.

„ 4. (*a*) Germinating spores in different stages.
(*b*) Promycelia showing the "buckle-joint" × 400.

„ 5 Germ-tube entering the epidermal cells of the young hypocotyl of the millet seedling × 400.

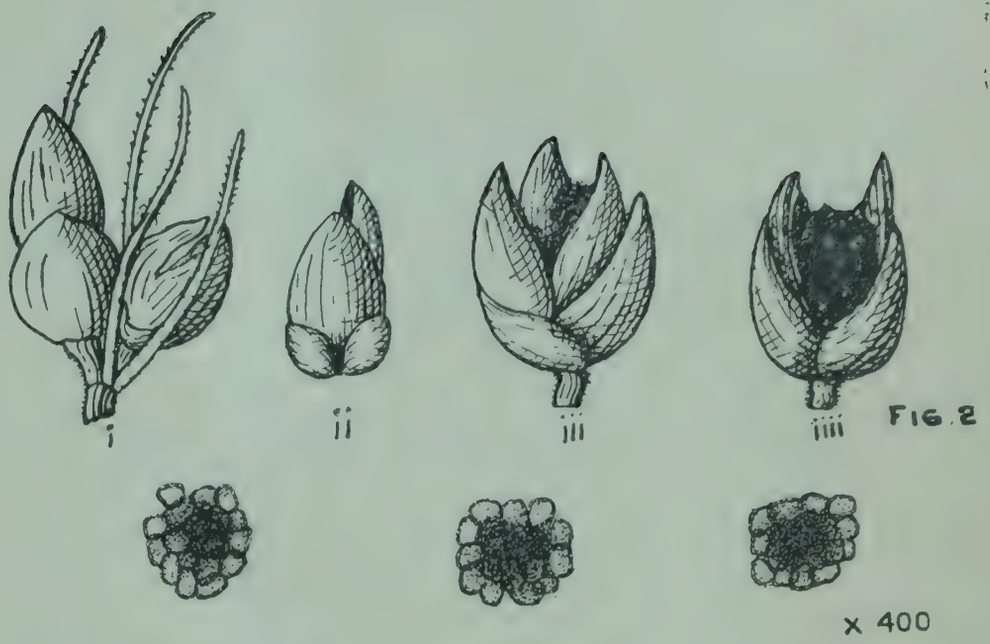


FIG. 2

× 400

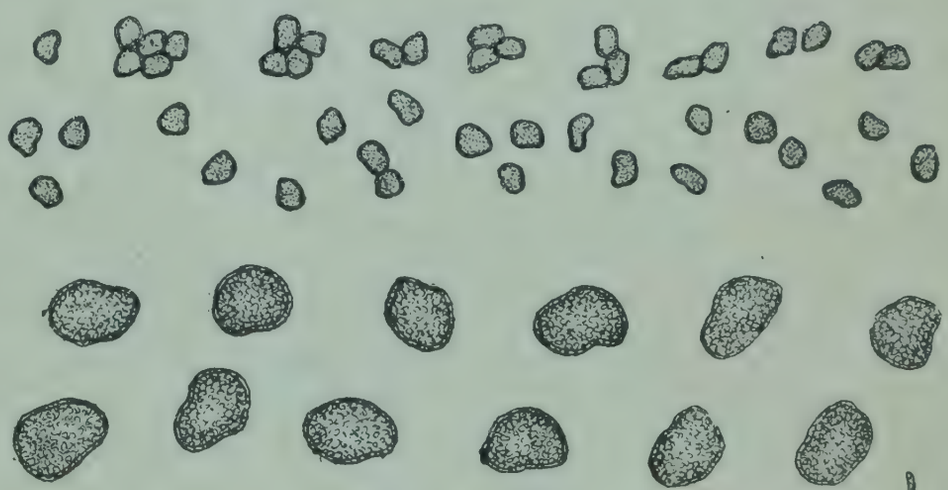


FIG. 3 ×800

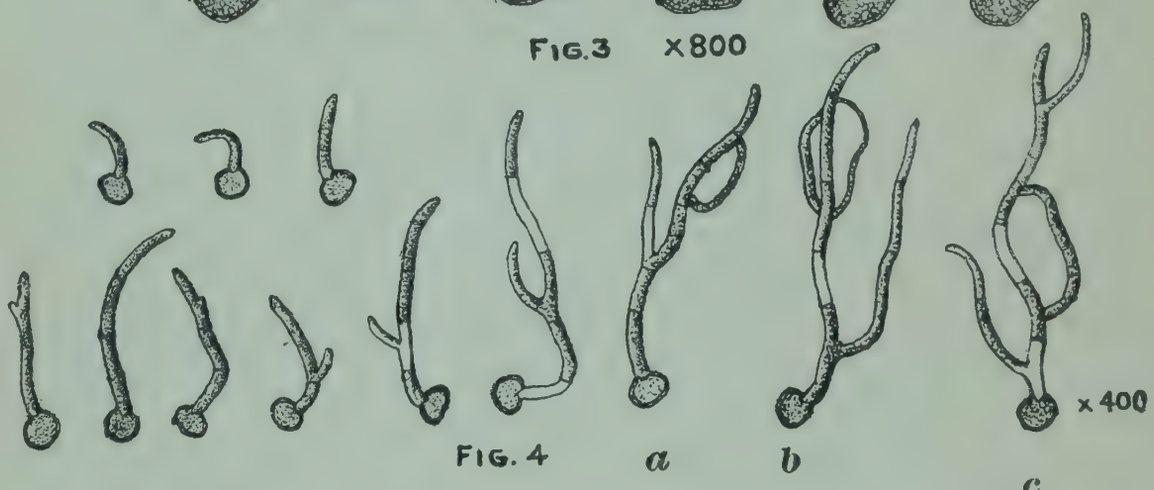


FIG. 4 *a* *b* *c* ×400

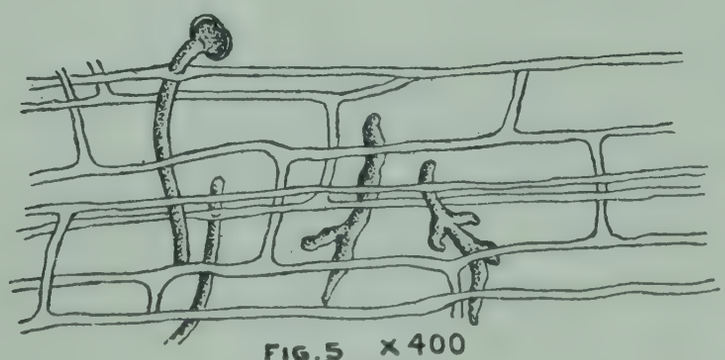
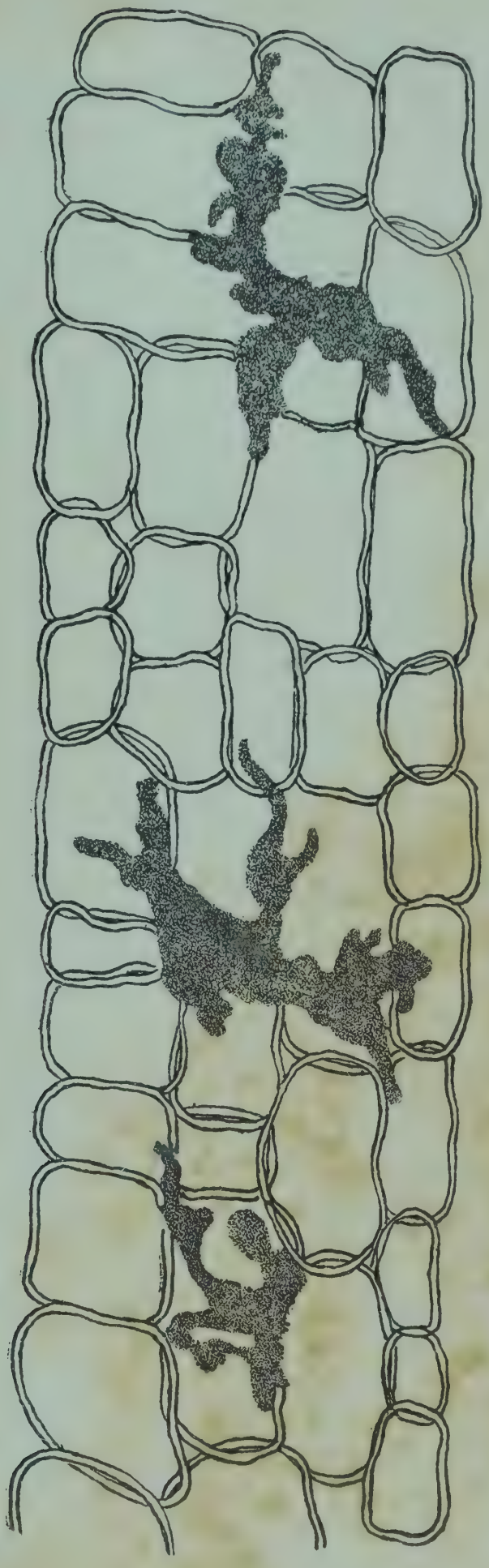


FIG. 5 ×400

Ustilago Crameri Koernon *Setaria italica.*



× 500

Hyphæ in sections of the internodes.

The Course that Surra runs in Camels when naturally contracted and when artificially inoculated.

[*Received for publication on 22nd March 1920.*]

I. Naturally contracted Surra.

Many Punjabi camelmen maintain that camels once infected with surra never recover: on the other hand many camelmen state that if a camel infected with surra lasts over three years the camel finally recovers, improves in condition and becomes immune to the disease.

To ascertain the course that surra runs in the camel, 11 camels suffering from surra and in fair condition were obtained from Silladar Camel Corps, some in the latter part of 1914 and some in the early part of 1915. From their condition and history it is probable that these 11 camels contracted surra during the 1914 fly season. Of these 11 camels 9 have died and 2 are still alive. These camels were kept under the most favourable conditions, being given in addition to browsing a ration of grain and *bhoosa*, and when green fodder was available this was substituted for *bhoosa*. The camels were given no work. The blood of each camel was daily examined and a record kept of the presence or absence of trypanosomes. Details of the paroxysms and intervals between the paroxysms, and a history of each camel while under observation is given.

In addition to these 11 camels, seven camels belonging to a villager who lived near Sohawa were diagnosed by me on the 29th September 1913 to be suffering from surra. During the hot weather these camels were not worked and periodical visits were made to ascertain how these camels were "doing." During the cold weather they worked in Amballa and Amritsar Districts. Within $1\frac{1}{2}$ years 2 males had died, and the *dachi* had aborted; within $2\frac{1}{2}$ years 5 out of the 7 had died and in less than 3 years all 7 were dead.

II. Artificially inoculated Surra.

To ascertain whether there is any difference in the course that the disease runs when naturally acquired and when artificially inoculated, four young camels, aged from $2\frac{1}{2}$ months to 1 year and one old camel aged 18 years, were inoculated with 1 c.c. of blood from a camel suffering from surra. These camels were kept under the same conditions as the 11 camels that had naturally contracted surra. The blood was daily

examined and a record of the absence or presence of trypanosomes kept. Details of the paroxysms, and a history of each camel while under observation is given.

I. NATURALLY CONTRACTED SURRA.

Camel No. 1.

Aged 6 years when trypanosomes were first observed in the blood.

Paroxysms	No. of days interval between paroxysms
1st – 2nd	7
2nd – 3rd	9
3rd – 4th	56
4th – 5th	9
5th – 6th	22
6th – 7th	12
7th – 8th	6
8th – 9th	20
9th – 10th	13
10th – 11th	7
11th – 12th	22
12th – 13th	5
13th – 14th	2
14th – 15th	10
15th – 16th	26
16th – 17th	8
17th – 18th	7
18th – 19th	9
19th – 20th	8
20th – 21st	19
21st – 22nd	12
22nd – 23rd	6
23rd – 24th	20
24th – 25th	43
25th – 26th	18
26th – 27th	27
27th – 28th	188
28th – 29th	179
29th – 30th	257
30th – 31st	135
31st – 32nd	480

Died 37 days after the last paroxysm.

Lived 4 years 11 months 20 days after being diagnosed to be infected with surra.

This camel showed more intestinal disturbance than any of the other camels. He had frequent attacks of diarrhœa. He developed oedema of the belly and hind legs, suffered from very severe mange, and was periodically off feed or only feeding slowly; for some time before death took place he had severe diarrhœa.

On *post mortem* nothing abnormal but extreme emaciation.

Camel No. 2.

Aged 6 years when trypanosomes were first observed in the blood.

Paroxysms	No. of days interval between paroxysms
1st	
	5
2nd	
	4
3rd	
	5
4th	
	52
5th	
	10
6th	
	5
7th	
	5
8th	
	28
9th	
	6
10th	
	50
11th	
	12
12th	
	8
13th	
	16
14th	

Paroxysms	No. of days interval between paroxysms
14th	
	18
15th	
	7
16th	
	13
17th	
	7
18th	
	9
19th	
	6
20th	
	8
21st	
	6
22nd	
	6
23rd	
	6
24th	
	17
25th	
	17
26th	
	19
27th	
	1
28th	

Camel No. 2—*concld.*

Paroxysms	No. of days interval between paroxysms
28th	
	86
29th	
	42
30th	
	8
31st	
	19
32nd	
	7
33rd	
	8
34th	
	5
35th	
	90
36th	
	9
37th	
	18
38th	
	44
39th	
	6
40th	
	12
41st	
	8
42nd	
	13
43rd	
	9
44th	
	30
45th	
	9
46th	

Paroxysms	No. of days interval between paroxysms
46th	
	14
47th	
	41
48th	
	9
49th	
	28
50th	
	30
51st	
	11
52nd	
	28
53rd	
	13
54th	
	10
55th	
	20
56th	
	14
57th	
	33
58th	
	49
59th	
	41
60th	
	53
61st	
	450
62nd to 31st January 1920.	176 still alive.

Fig. 1. Camel No. 2.

Fig. 2. Camel No. 3.
(This camel died on 4th March 1920)

Five years 3 months and 5 days under observation.

This camel kept his condition well until the last few months when he has been losing condition rapidly. During the paroxysms he was often off feed or feeding only fairly, he developed swelling and suppuration of the inquinal glands and has suffered during the cold weather months from mange. It is unlikely that he will "last out" another year, as although his condition is fair he is very lifeless. (Plate I, fig. 1.)

Camel No. 3.

Aged 7 years when trypanosomes were first observed in the blood.

Paroxysms	No. of days interval between paroxysms
1st	
2nd	6
3rd	4
4th	6
5th	7
6th	45
7th	8
8th	93
9th	9
10th	8
11th	1
12th	10
13th	19
14th	19
15th	7
16th	9
17th	9
18th	6
19th	78
19th	29
20th	9
21st	10
22nd	9
23rd	142
24th	13
25th	26
26th	9
27th	11
28th	46
29th	157
30th	77
31st	284
32nd	526
33rd	42
34th	37
35th	72
36th	28 days up to 31st January 1920 alive.

Five years 3 months 5 days under observation.

This camel is still alive (31st January 1920) and has been under observation 5 years 3 months 5 days. As will be seen from the

photograph Plate I, fig. 2 the hump has disappeared and the animal is in a condition of emaciation. He fed well the whole time except when trypanosomes were present in the peripheral circulation when he was sometimes off feed or fed only fairly. His condition varied considerably, sometimes he fell off in condition then picked up again ; during the last three months (cold weather) he lost condition rapidly and [will probably die within a month. During each cold weather he suffered badly from mange and developed oedema under the belly.

Camel No. 4.

Aged 8 years when trypanosomes were first observed in the blood.

Paroxysms	No. of days interval between paroxysms
1st	
2nd	8
3rd	20
4th	22
5th	6
6th	57
7th	8
8th	12
9th	9
10th	7
11th	5
12th	7
13th	9
14th	21

Paroxysms	No. of days interval between paroxysms
14th	
15th	17
16th	26
17th	7
18th	22
19th	30
20th	16
21st	3
22nd	21
23rd	18
24th	129
25th	18
26th	51
27th	24
28th	104

Died 38 days after the last paroxysm.

Lived 2 years 28 days after being diagnosed to be infected with surra.

This camel developed oedema under the belly, suffered very severely from mange, was often off feed during the paroxysms, became very thin and weak and had acute diarrhœa for some days before he died.

Post mortem revealed nothing but emaciation.

Camel No. 5.

Aged 8 years when trypanosomes were first observed in the blood.

Paroxysms	No. of days interval between paroxysms
1st	
	6
2nd	
	19
3rd	
	22
4th	
	36
5th	
	9
6th	
	11
7th	
	11
8th	
	7
9th	
	12
10th	
	11
11th	

Paroxysms	No. of days interval between paroxysms
11th	
	105
12th	
	19
13th	
	90
14th	
	61
15th	
	44
16th	
	9
17th	
	11
18th	
	11
19th	
	186
20th	
	269
21st	

Died 9 days after the last paroxysm.

Lived 2 years 9 months 1 day after being diagnosed to be infected with surra.

This camel was the only one amongst those kept under observation that showed any pneumonic symptoms. He suffered severely from mange. Occasionally would eat earth, was periodically off feed or only

feeding fairly and in the later stages of the disease was " coughing badly." Some time before he died he had severe diarrhœa.

Post mortem : abscesses in the lungs and extreme emaciation.

Camel No. 6.

Aged 9 years when trypanosomes were first observed in the blood.

Paroxysms	No. of days interval between paroxysms	Paroxysms	No. of days interval between paroxysms
1st		4th	
	80		55
2nd		5th	
	23		146
3rd		6th	
	14		168
4th		7th	
			26
		8th	

Died 167 days after the last paroxysm.

Lived 2 years 16 days after being diagnosed to be infected with surra.

This camel was a very fine specimen of a camel when first diagnosed to be suffering from surra. During the first six months while he was under observation he lost condition rapidly, after this the loss of condition was much slower. He suffered severely from mange and became very weak, for some time before he died he had very watery diarrhœa. He was periodically off feed or only feeding fairly.

On *post mortem* : extreme emaciation and abscess in the left kidney.

Camel No. 7.

Aged 9 years when trypanosomes were first observed in the blood.

Paroxysms	No. of days interval between paroxysms	Paroxysms	No. of days interval between paroxysms
1st		5th	
	4		13
2nd		6th	
	2		20
3rd		7th	
	4		15
4th		8th	
	52		7
5th		9th	
			9
		10th	

CAMEL No. 7—*concld.*

Paroxysms	No. of days interval between paroxysms	Paroxysms	No. of days interval between paroxysms
10th		25th	
	27		9
11th		26th	
	9		97
12th		27th	
	8		50
13th		28th	
	7		10
14th		29th	
	37		7
15th		30th	
	2		11
16th		31st	
	45		28
17th		32nd	
	8		1
18th		33rd	
	9		64
19th		34th	
	12		44
20th		35th	
	10		110
21st		36th	
	10		44
22nd		37th	
	10		137
23rd		38th	
	45		335
24th		39th	
	10		90
25th		40th	

Died 120 days after the last paroxysm.

Lived 4 years 6 months 11 days after being diagnosed to be infected with surra.

Filaria were frequently seen in the blood of this camel. He had one attack of severe colic, suffered severely from mange, was periodically off feed or only feeding fairly and in the later stages of the disease lost condition rapidly.

On *post mortem* nothing abnormal with the exception of extreme emaciation.

(Search was not made for filarial parasites.)

Camel No. 8.

Aged 9 years when trypanosomes were first observed in the blood.

Paroxysms	No. of days interval between paroxysms
1st	
	7
2nd	
	2
3rd	
	7
4th	
	22
5th	
	15
6th	
	10
7th	
	8
8th	
	8
9th	
	14
10th	
	18
11th	
	15
12th	
	5
13th	
	7
14th	
	8
15th	
	2
16th	

Paroxysms	No. of days interval between paroxysms
16th	
	11
17th	
	9
18th	
	19
19th	
	10
20th	
	22
21st	
	17
22nd	
	26
23rd	
	97
24th	
	12
25th	
	11
26th	
	12
27th	
	11
28th	
	4
29th	
	7
30th	
	53
31st	
	1
32nd	

Died 162 days after the last paroxysm.

Lived 1 year 11 months 5 days after being diagnosed to be infected with surra.

This camel developed oedema under the belly and a short time before death, oedema of the fore legs. Enlargement and suppuration of the inquinal glands was observed. He suffered from mange during the cold weather months; he gradually lost condition becoming finally so weak, that he was unable to get up without assistance. During the paroxysms he was periodically off feed or feeding only fairly.

On *post mortem* nothing abnormal with the exception of emaciation and suppuration of the inquinal glands.

Camel No. 9.

Aged 10 years when trypanosomes were first observed in the blood.

Paroxysms	No. of days interval between paroxysms	Paroxysms	No. of days interval between paroxysms
1st		10th	
	8		21
2nd		11th	
	10		36
3rd		12th	
	10		64
4th		13th	
	11		90
5th		14th	
	7		61
6th		15th	
	9		31
7th		16th	
	9		27
8th		17th	
	22		12
9th		18th	
	8		93
10th		19th	
			124
		20th	

Died 251 days after the last paroxysm.

Lived 2 years 6 months 3 days after being diagnosed to be infected with surra.

This camel developed slight oedema of both fore and hind legs, was periodically off feed or feeding only fairly. During the cold weather suffered from mange and lost condition gradually.

On *post mortem* nothing abnormal with the exception of extreme emaciation.

CAMEL No. 10.

Aged 10 years when trypanosomes were first observed in the blood.

Paroxysms	No. of days interval between paroxysms	Paroxysms	No. of days interval between paroxysms
1st		11th	
	19		19
2nd		12th	
	67		20
3rd		13th	
	6		40
4th		14th	
	9		28
5th		15th	
	10		37
6th		16th	
	17		72
7th		17th	
	2		24
8th		18th	
	5		90
9th		19th	
	8		16
10th		20th	
	30		41
11th		21st	
			116
		22nd	

Died 122 days after the last paroxysm.

Lived 2 years 3 months 21 days after being diagnosed to be infected with surra.

Filaria were frequently observed in the blood of this camel. (Filariasis is very common in the camel and does not appear to have a very harmful effect.) This camel was periodically off feed or feeding only fairly, became gradually weaker and weaker and for some time before death took place suffered from diarrhœa.

On *post mortem* nothing abnormal but extreme emaciation.

(Search was not made for the filarial parasite.)

Camel No. 11.

Aged 11 years when trypanosomes were first observed in the blood.

Paroxysms	No. of days interval between paroxysms
1st – 2nd	15
2nd – 3rd	15
3rd – 4th	19
4th – 5th	10
5th – 6th	9
6th – 7th	7
7th – 8th	17
8th – 9th	5
9th – 10th	10
10th – 11th	18
11th – 12th	9
12th – 13th	34

Paroxysms	No. of days interval between paroxysms
13th – 14th	28
14th – 15th	59
15th – 16th	108
16th – 17th	19
17th – 18th	19
18th – 19th	17
19th – 20th	19
20th – 21st	14
21st – 22nd	9
22nd – 23rd	9
23rd – 24th	25
24th – 25th	30

Died 48 days after the last paroxysm.

Lived 1 year 8 months 12 days, after being diagnosed to be infected with surra.

This camel lost condition very rapidly, he was very frequently only feeding fairly, he became thinner and thinner and finally became so weak that he was unable to " get up " without assistance.

On *post mortem* nothing abnormal with the exception of ecchinococcus cysts in the lungs and extreme emaciation.

II. CAMELS INOCULATED WITH SURRA.

Camel No. 12.

Aged 18 years when inoculated with 1 c.c. blood from camel suffering from surra.

This camel was obtained from the 52nd Silladar Camel Corps in 1915. According to the books of the Corps this camel on enlistment was 5 years old and his total length of service was over 13 years ; his age therefore was over 18 years and he was in fair condition. He was proved to be free from surra by examination of the blood and by the injection of blood into rabbits and guinea pigs which remained healthy.

He was inoculated with 1 c.c. blood from a camel suffering from surra. On the seventh day after inoculation trypanosomes appeared in the peripheral circulation and with the exception of one day, were continuously present in the peripheral circulation till he died. The camel rapidly lost condition, did not feed well and died 18 days after inoculation.

On *post mortem* nothing abnormal but emaciation.

Camel No. 13.

Aged 2½ months when inoculated with 1 c.c. blood from camel suffering from surra.

Paroxysms	No. of days interval between paroxysms
1st	
2nd	4
3rd	3
4th	9
5th	4
6th	3
7th	8
8th	6
9th	8
10th	6
11th	13
12th	17
12th	
13th	8
14th	6
15th	8
16th	28
17th	42
18th	45
19th	69
20th	9
21st	74
22nd	265
23rd	58
to 31st January 1920	193 alive

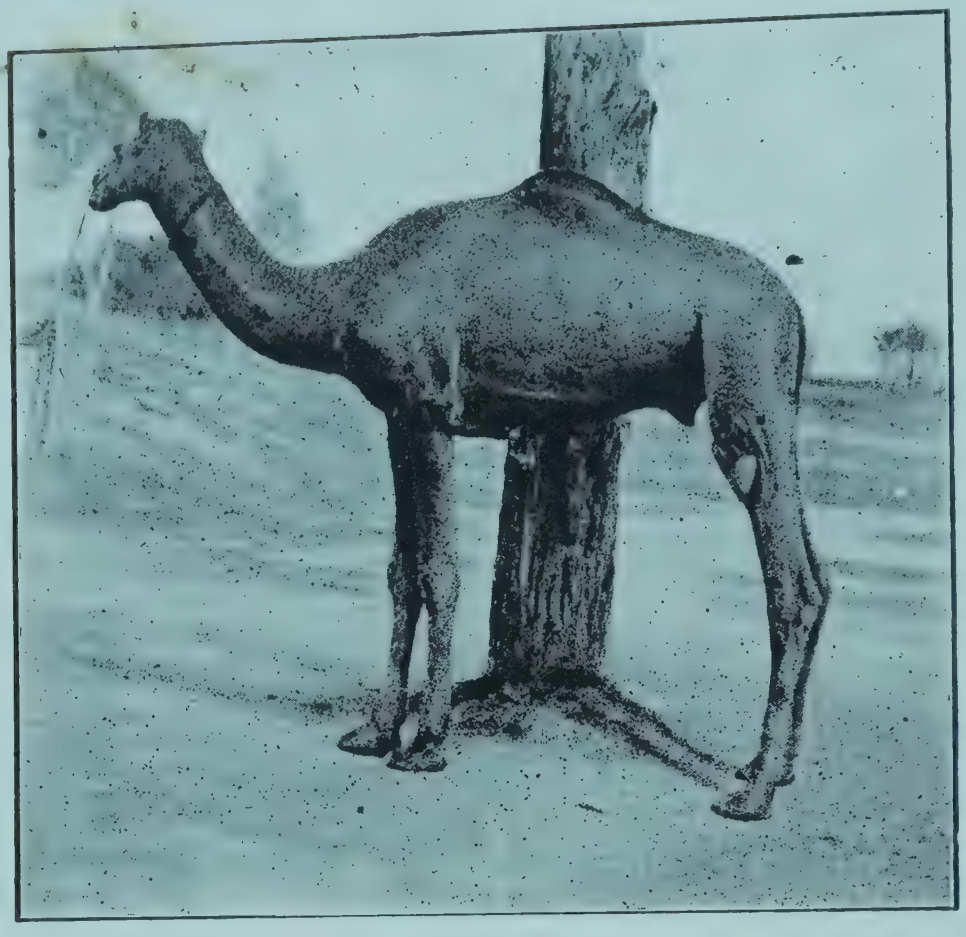


Fig. 1. Camel No. 13.

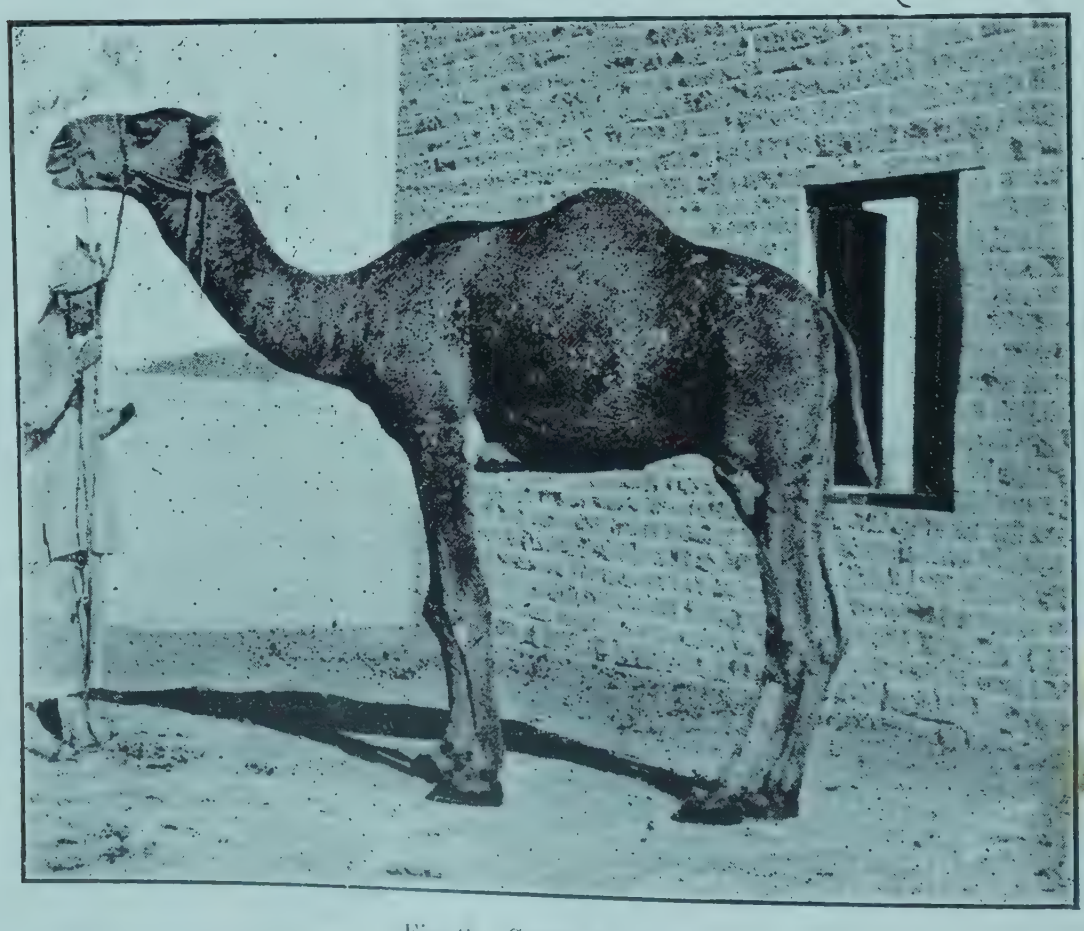


Fig. 2. Camel No. 14.

Two years 8 months 4 days under observation.

This camel was in fair condition when inoculated with surra and, though he developed camel pox, did not lose much condition. During the cold weather months has suffered from mange. He is at present in fair condition 2 years 8 months 4 days after inoculation. (Plate II, fig. 1.)

Camel No. 14.

Aged 1 year when inoculated with 1 c.c. blood from camel suffering from surra.

Paroxysms	No. of days interval between paroxysms
1st to 2nd	4
2nd to 3rd	3
3rd to 4th	3
4th to 5th	4
5th to 6th	15
6th to 7th	15
7th to 8th	7
8th to 9th	20
9th to 10th	9
10th to 11th	8
11th to 12th	37
12th to 13th	48
13th to 14th	6
14th to 15th	632
15th to 16th	552
16th to 31st January 1920	145 alive.

Four years 3 months 11 days under observation.

This camel was in very poor condition when inoculated with surra. During the paroxysms was sometimes off feed or fed only fairly. During the cold weather months suffered from mange and with the exception of getting urticaria, which disappeared in a few days, has shown no other symptoms. He is at present in fair condition, 4 years 3 months 11 days after being inoculated. (Plate II, fig. 2.)

Camel No. 15.

Aged 1 year when inoculated with 1 c.c. blood from camel suffering from surra.

Paroxysms	No. of days interval between paroxysms
1st	
	4
2nd	
	6
3rd	
	2
4th	
	4
5th	
	1
6th	
	5
7th	
	47
8th	
	10
9th	
	85
10th	
	33
11th	
	7
12th	
	455
13th	
	70
14th to 31st January 1920	779 alive.

Four years 3 months 11 days under observation.

This camel was in very bad condition when inoculated with surra. During the paroxysms he frequently fed only fairly and sometimes was " off his feed " altogether. He suffered for a short time from dysentery, during which time he would eat earth. Swelling of the parotid gland was noticed, but after 18 days the swelling disappeared. During the cold weather months suffered from mange. He improved in condition and is now in fair condition, 4 years 3 months 11 days after being inoculated. (Plate III, fig. 1.)

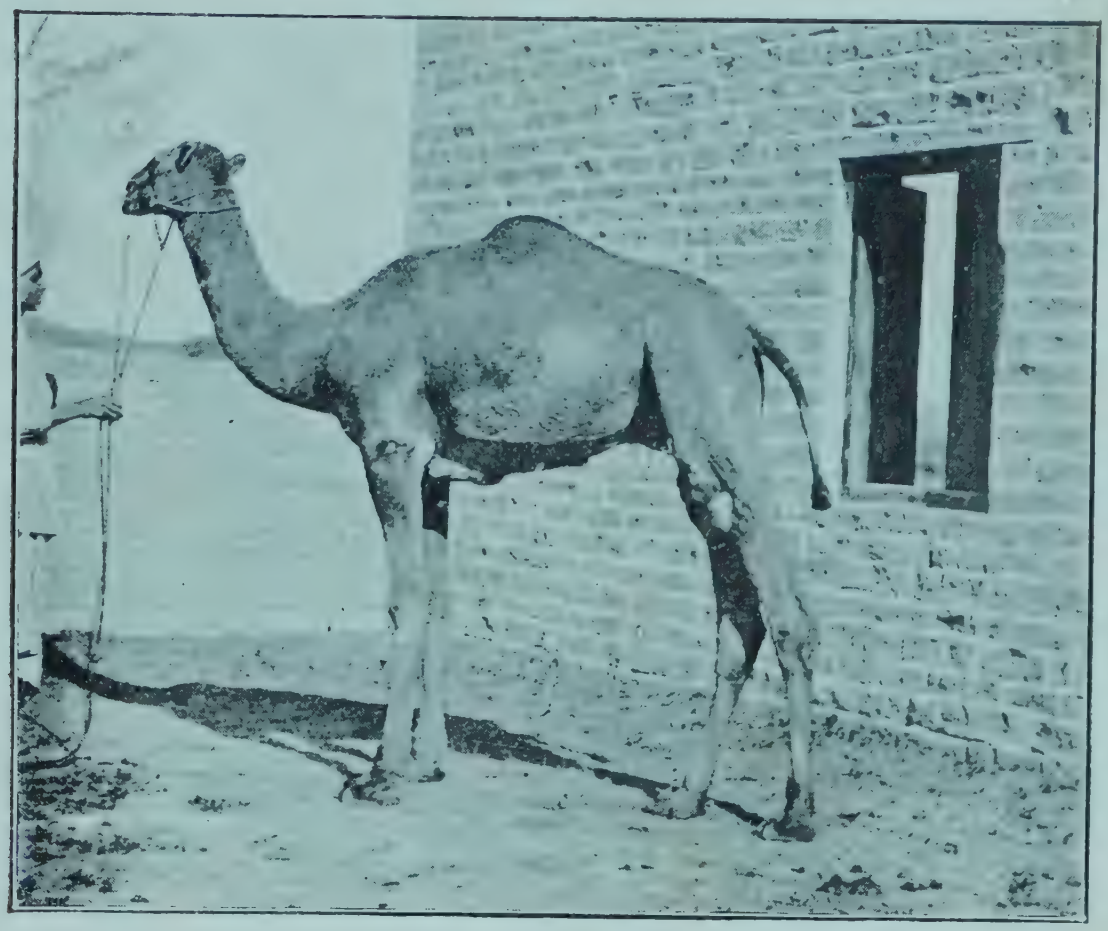


Fig. 1. Camel No. 15.

Fig. 2. Camel No. 16.

Camel No. 16.

Aged 1 year when inoculated with 1 c.c. blood from camel suffering from surra.

Paroxysms	No. of days interval between paroxysms
1st	
2nd	8
3rd	27
4th	38
5th	15
6th	1
7th	18
8th	8
9th	146
10th	23
11th	46
12th	10
13th	26
14th	17
15th	11
16th	56
17th	62
18th	55
19th	23
20th	55
21st	9
22nd	36
23rd	21
24th	12
25th	25
26th	103
27th	186
to 31st January 1920	519 alive

Four years 3 months 11 days under observation.

This was a female camel and when inoculated with surra was in very poor condition. During the time this animal has been under observation with exception of periodically " feeding fairly "and suffering from mange during the cold weather months, no other symptoms developed.

She is now in fair condition, 4 years 3 months 11 days after being inoculated. (Plate III, fig. 2.)

SUMMARY OF CAMELS INFECTED WITH SURRA (NATURALLY ACQUIRED).

Camel No.	Age when diagnosed	Time under observation			Result
	Years	Y.	M.	D.	
1	6	4	11	20	Died.
2	6	5	3	5	Alive, condition fair.
3	7	5	3	5	*Alive, condition very poor.
4	8	2	0	28	Died.
5	8	2	9	1	Do.
6	9	2	0	16	Do.
7	9	4	6	11	Do.
8	9	1	11	5	Do.
9	10	2	6	3	Do.
10	10	2	3	21	Do.
11	11	1	8	12	Do.

SUMMARY OF CAMELS INOCULATED WITH SURRA.

12	18	0	0	18	Died 18 days after inoculation.
13	2½ months	2	8	4	Alive, condition fair.
14	1 year	4	3	11	Do.
15	1 ,,	4	3	11	Do.
16	1 ,,	4	3	11	Do.

* This camel died on 4th March 1920.

Remarks.

1. Out of the 11 camels that had been naturally infected with surra, only two are still alive ; of these 2, one is at the point of death and the other is losing condition rapidly.

The time a surra-infected camel lives probably depends to a great extent upon the age of the camel when he became infected.

In the case of the camels artificially inoculated with surra, the 18 year old camel showed very little resistance to the disease compared to the four very young camels, which showed very great resistance and they may recover.

2. It is unlikely that camels that become infected with surra after six years of age and are worked ever recover from the disease ; whether those that become infected when very young, recover, remains to be ascertained.

3. In the early stages of surra the paroxysms, in the majority of cases, are far more frequent than in the later stages.

4. Diarrhœa is a frequent symptom in the later stages of the disease.

5. Mange produces very rapid loss of condition in surra-infected camels.

6. Swelling and suppuration of the inquinal glands is frequently seen in surra-infected camels.

7. Surra-infected camels when stall-fed often feed well even during the paroxysms, but if out browsing during the paroxysms they do not browse well, they " hang about " and do not go from tree to tree like a camel in normal health, they can at once be seen to be sick.

8. Oedema of the belly and legs is sometimes seen in camels suffering from surra.

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The Course that Camel Surra runs in Ponies, Buffaloes and other Animals

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The Course that Camel Surra runs in Ponies, Buffaloes and other Animals.

(*Received for publication on 22nd March 1920.*)

During investigations into surra amongst Silladar Camel Corps and other military camels, it had often been noticed that although a large number of camels were detected to be suffering from surra, amongst the ponies and mules, which were kept in close proximity to camels during the fly season, practically no cases of surra had been observed.

It appeared to me it was possible that ponies and mules did become infected, but that it was probable that these animals when infected with camel surra, did not show the same symptoms as are usually met with in horse surra and consequently the disease may have escaped detection.

It was decided, therefore, to ascertain the course that camel surra runs in ponies and other animals, and with this object in view, ponies, buffaloes, goats, sheep, dogs, rabbits and guinea pigs were inoculated with blood from camels suffering from surra and a daily blood examination of each animal was made and a history sheet of each kept.

The animals were kept under very favourable conditions ; the ponies were not worked but were given regular exercise.

Sometime after these experiments were started a severe outbreak of surra occurred amongst the camels of a Silladar Camel Corps.

Though many of the camels were infected with surra and tabanidæ were at the time very numerous, the ponies attached to the Corps (kept only a short distance away from the camels, circumstances over which the Commandant of the Corps had no control did not permit of the ponies being kept far away from the camels) were in excellent condition and appeared in perfect health. I asked the Commandant to have a daily blood examination made of these ponies and he very kindly consented to do so.

After a time the Commandant informed me that 5 out of the 14 ponies had been detected to be suffering from surra.

Unfortunately the 5 ponies were immediately shot when detected to be surra-infected, so they could not be procured to be kept under observation.

Pony No. 1.

Aged 8 months when inoculated with 1 c.c. blood from camel suffering from surra.

11 days after inoculation, trypanosomes appeared in the blood.

718 days after inoculation, partial paralysis of hind legs.

761 days after inoculation, unable to get up without assistance.

878 days after inoculation, died.

This pony improved in condition, and was in fair condition (718 days after inoculation) when partial paralysis of the hind legs was observed. After this he began to lose condition and got weak. He got gradually weaker and finally was unable to get up, and died 2 years 8 months 28 days after inoculation.

Post mortem examination revealed nothing but emaciation.

Lived 2 years 8 months and 28 days after being inoculated.

Paroxysm	No. of days interval between paroxysms	Paroxysm	No. of days interval between paroxysms
1st to 2nd	15	18th to 19th	6
2nd to 3rd	6	19th to 20th	7
3rd to 4th	3	20th to 21st	26
4th to 5th	9	21st to 22nd	83
5th to 6th	6	22nd to 23rd	1
6th to 7th	5	23rd to 24th	17
7th to 8th	1	24th to 25th	3
8th to 9th	4	25th to 26th	26
9th to 10th	8	26th to 27th	27
10th to 11th	5	27th to 28th	7
11th to 12th	25	28th to 29th	24
12th to 13th	20	29th to 30th	10
13th to 14th	5	30th to 31st	42
14th to 15th	12	31st to 32nd	39
15th to 16th	14	32nd to 33rd	51
16th to 17th	5	33rd to 34th	124
17th to 18th	21	34th	died 163 days after last paroxysm.

Fig. 1. Pony No. 2. (Photograph taken 3 years, 2 months and 4 days after inoculation.)

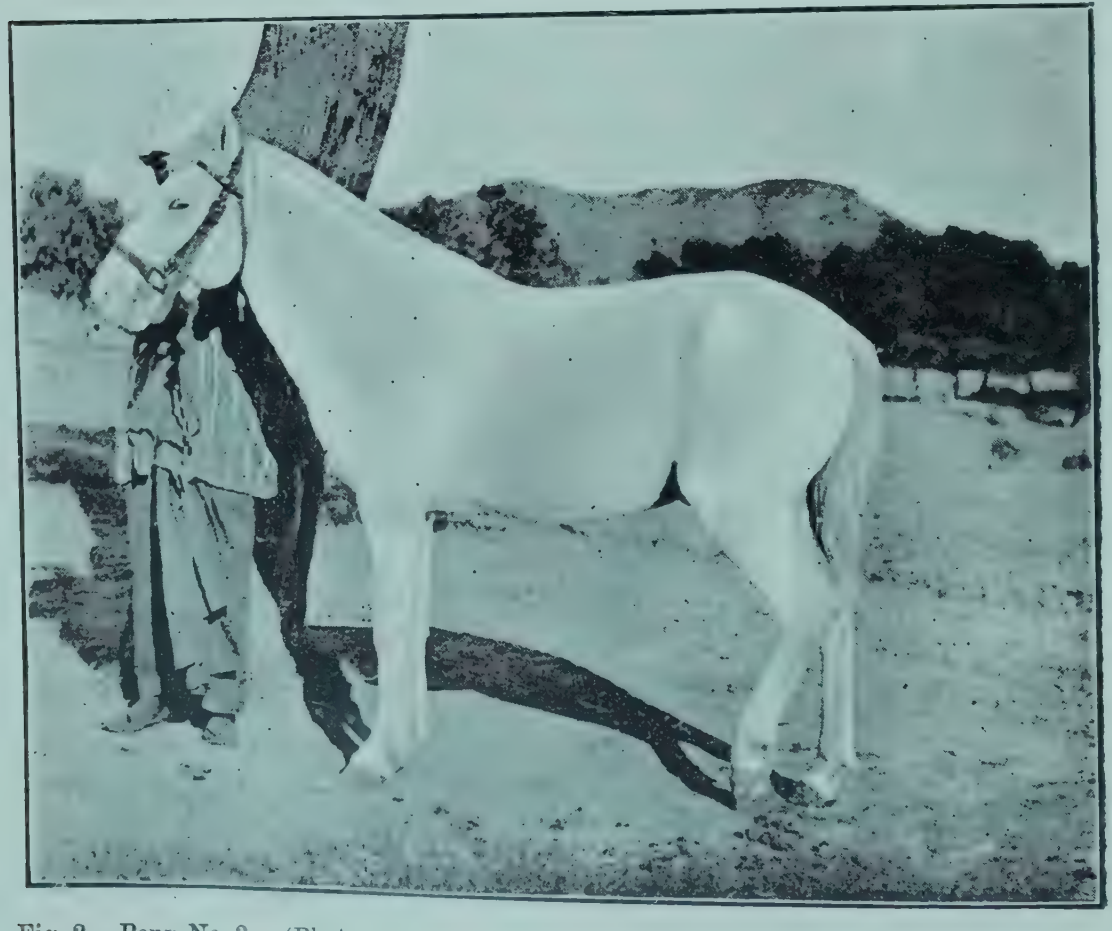

Fig. 2. Pony No. 3. (Photograph taken 3 years, 7 months and 25 days after inoculation.)

Pony No. 2.

Aged 1 year when inoculated with 1 c.c. blood from camel suffering from surra.

Five days after inoculation, trypanosomes appeared in the blood. The pony was in poor condition when inoculated, but has improved and is at present in very fair condition. Up to the 19th paroxysm the intervals between the paroxysms were short but the intervals between the last 3 paroxysms were very long and from the last paroxysm up to the present time (460 days) no trypanosomes have appeared in the blood. Two guinea pigs were inoculated with a small quantity of blood; 354 days after the last paroxysm, both showed trypanosomes in their blood, showing that the blood of this pony was still infective. The pony appears to be in normal health and has been under observation 3 years 2 months 19 days. (*See* fig. 1 of the Plate.)

Paroxysm	No. of days interval between paroxysms	Paroxysm	No. of days interval between paroxysms
1st		11th	
	2		3
2nd		12th	
	1		13
3rd		13th	
	1		7
4th		14th	
	4		4
5th		15th	
	20		19
6th		16th	
	12		12
7th		17th	
	13		21
8th		18th	
	1		59
9th		19th	
	5		132
10th		20th	
	39		311
11th		21st	
			460 till 31-1-1920 alive.

Three years 2 months 19 days under observation.

Pony No. 3.

Aged 6 months old when inoculated with 1 c.c. of blood from a camel suffering from surra.

Eight days after inoculation, trypanosomes appeared in the blood.

This pony was in fair condition when inoculated with surra and has never lost condition; at the present time (3 years 8 months 10 days after inoculation) he is in excellent condition.

The interval between the 9th and 10th paroxysm was 837 days. 175 days after the 9th paronysm one guinea pig and one rabbit were injected, with a small quantity of blood; after 76 days the rabbit was destroyed, no trypanosomes having been found; the guinea pig died after 45 days but no trypanosomes were found in the blood.

251 days after the 9th paroxysm a guinea pig and a rabbit were injected with a small quantity of blood; they were destroyed after 61 days, no trypanosomes being found in the blood of either.

In order to test whether he was immune to trypanosomiasis, 806 days after the 9th paroxysm he was injected with 1 c.c. of blood from a pony which has been inoculated with camel surra. He had a high rise in temperature 8 days after inoculation; trypanosomes were found in the blood 30 days later; but no trypanosomes have again been found up to the present (31st January 1920) (128 days). The pony is in excellent condition. (*See* fig. 2 of the Plate.)

Been under observation 3 years 8 months and 10 days.

Paroxysm	No. of days interval between paroxysms	Paroxysm	No. of days interval between paroxysms
1st		6th	
2nd	1	7th	183
3rd	3	8th	29
4th	22	9th	87
5th	3	10th	837
6th	10		till 31-1-1920 (128 days) alive.

Three years 8 months 10 days under observation.

Pony No. 4.

Aged 3½ years when inoculated with 1 c.c. blood from a camel suffering from surra.

7 days after inoculation, trypanosomes appeared in the blood.

369 days after inoculation, last appearance of trypanosomes in the blood.

482 days after inoculation, pony showed signs of loss of control of the hind legs ; this partial loss of control over the hind legs continued till he died.

509 days after inoculation, pony was constipated and brain symptoms developed. The constipation was relieved by linseed oil. The pony walked round in a circle with head turned towards near side, he was off feed and continued to circle, falling down at intervals, till he died four days later.

513 days after inoculation, died.

Post mortem examination revealed nothing but a very bad-smelling blood-coloured fluid in the right frontal sinus.

In the early stages of the disease the paroxysms were frequent but gradually diminished in frequency. For 144 days before death trypanosomes were absent from the peripheral circulation.

The pony improved in condition and on the day that cerebral symptoms developed was in excellent condition.

Lived 1 year 4 months 26 days after being inoculated.

Pony No. 5.

Aged 4½ years when inoculated with 1 c.c. blood from camel suffering from surra.

8 days after inoculation, trypanosomes appeared in the blood.

289 days after inoculation, last appearance of trypanosomes in the blood.

415 days after inoculation, pony showed slight loss of control of hind legs.

468 days after inoculation, started walking round in a circle or took a few paces backwards and then in a circle ; when attempting to drink kept head on one side, and ate very little.

478 days after inoculation was constipated, the constipation was relieved by linseed oil.

494 days after inoculation, again constipated, relieved by a dose of linseed oil.

498 days after inoculation, cerebral symptoms developed; pony kept head on one side, could not open jaws properly and ate practically nothing.

500 days after inoculation, there was a slight discharge from the right nostril; he continued going round in a circle, falling down at intervals, till he died.

505 days after inoculation, died.

Post mortem examination revealed nothing but pus in the right frontal sinus.

The pony improved greatly in condition and was in excellent condition when cerebral symptoms developed.

In the early stages of the disease the paroxysms were frequent; they became gradually less frequent and for 216 days before death took place, no trypanosomes were found in the blood.

Lived 1 year 4 months 16 days after being inoculated.

Pony No. 6.

Aged 5 years when inoculated with 1 c.c. of blood from camel suffering from surra.

9 days after inoculation, trypanosomes appeared in the blood.

195 days after inoculation, got colic which was relieved by treatment.

198 days after inoculation, developed cerebral symptoms; moving head from side to side like a "weaver."

205 days after inoculation, commenced to go round in a circle and had only partial control over the hind legs; the following day was acting unconsciously, throwing his head up and knocking it against the wall. He broke out into a profuse perspiration and fell down; he lay perfectly quiet, dying 4 days later.

During the course of the disease the pony improved in condition and when cerebral symptoms developed was in excellent condition. Filaria was observed in the blood of this pony.

On *Post mortem* examination nothing abnormal was discovered.

Paroxysm	No. of days interval between paroxysms	Paroxysm	No. of days interval between paroxysms
1st		6th	
2nd	5	7th	41
3rd	5	8th	12
4th	1	9th	4
5th	1	10th	5
6th	18	11th	42
		12th	30

Death took place 16 days after last paroxysm. Lived 6 months 28 days after being inoculated.

Pony No. 7.

Aged 5½ years when inoculated with 1 c.c. of blood from a camel suffering from surra.

7 days after inoculation, trypanosomes appeared in the circulation.

43 days after inoculation, died.

The paroxysms were very frequent, the pony got weaker and weaker and lost condition ; death taking place 36 days after the first appearance of trypanosomes in the blood.

Post mortem examination revealed nothing but extreme emaciation.

Lived 43 days after being inoculated.

Pony No. 8.

This was a naturally infected case of surra and was obtained from a Camel Corps, being one of the ponies used by the Indian officers of the Corps. As this pony had been a considerable number of years with the Corps, it is probable it had contracted surra from the camels.

On being diagnosed to be suffering from surra it was handed over to me. It was in very fair condition and about ten years of age.

While under observation it was given the best of rations. It gradually lost condition and got weaker and weaker.

He showed no brain symptoms whatever but simply wasted away becoming so weak in the later stages of the disease that he was unable to stand.

Paroxysm	No. of days interval between paroxysms	Paroxysm	No. of days interval between paroxysms
1st . . 2nd	1	10th . . 11th	2
2nd . . 3rd	1	12th . .	5
3rd . . 4th	3	13th . .	5
4th . . 5th	3	14th . .	1
5th . . 6th	4	15th . .	1
6th . . 7th	2	16th . .	5
7th . . 8th	3	17th . .	1
8th . . 9th	2	18th . .	5
9th . . 10th	6	19th . . 20th	8 4 died during the last paroxysm.

Lived 4 months 28 days.

Post mortem examination, nothing abnormal but extreme emaciation.

Pony No. 9.

Aged about 13 years when inoculated with 1 c.c. blood from camel suffering from surra.

7 days after inoculation, trypanosomes appeared in the blood.

457 days after inoculation, cerebral symptoms developed, the pony showing a tendency to fall over backwards.

465 days after inoculation, was constipated, relieved by treatment.

468 days after inoculation, stood with head down and only moved when forced to ; off feed.

470 days after inoculation, commenced to circle round towards the left.

477 days after inoculation, died.

This pony improved greatly in condition and was in excellent condition when cerebral symptoms appeared.

Post mortem examination revealed nothing abnormal.

Paroxysm	No. of days interval between paroxysms	Paroxysm	No. of days interval between paroxysms
1st		10th	
	2		5
2nd		11th	
	4		1
3rd		12th	
	1		5
4th		13th	
	3		7
5th		14th	
	11		8
6th		15th	
	5		2
7th		16th	
	2		26
8th		17th	
	9	18th	45
9th		19th	
	5		8
10th		20th	29

Died 257 days after last paroxysm.

Lived 1 year 3 months and 20 days after being inoculated.

Pony No. 10.

About 13 years old when inoculated with 1 c.c. blood from camel suffering from surra.

4 days after inoculation, trypanosomes appeared in the blood.

232 days after inoculation, developed colic which was relieved by treatment.

403 days after inoculation, partial paralysis of the hind legs.

410 days after inoculation, died.

This pony improved in condition, and was in good condition when he developed partial paralysis of the hind legs. He finally lost all power of the hind legs and was unable to get up.

On *post mortem*, nothing abnormal.
Lived 1 year 2 months 13 days after being inoculated.

Summary.

No. of Pony	Age.	Time under observation			Result	Remarks.
		Years	Months	Days		
1	8 months	2	8	28	died	Paralysis of hind legs.
2	1 year .	3	2	19	alive	Showed no brain symptoms.
3	6 months	3	8	10	alive	Showed no brain symptoms.
4	3½ years	1	4	26	died	1. Partial paralysis of hind legs. 2 Cerebral symptoms. 3. Constipation.
5	4½ years	1	4	16	died	1. Parti paralysis of hind legs. 2. Constipation. 3. Brain symptoms.
6	5 years .	0	6	28	died	1. Colic. 2. Cerebral symptoms. 3. Partial paralysis of hind legs.
7	5½ years .	0	0	43	died	1. Lost condition rapidly. 2. Got gradually weaker. 3. Showed no other symptoms.
8	10 years .	0	4	28	died	1. Lost condition. 2. Got gradually weaker. 3. Showed no other symptoms.
9	13 years .	1	3	20	died	1, Cerebral symptoms. 2. Constipation.
10	13 years .	1	2	13	died	1. Colic. 2. Paralysis of hind legs.

Remarks. From these experiments it would appear that :—

(1) Ponies inoculated with camel surra, often do not lose condition and do not always die from gradual emaciation ; on the contrary, they frequently, when not worked, put on condition and live for several years.

(2) In some cases, in the later stages of the disease the intervals between the paroxysms may be very long, extending over more than a year.

(3) Constipation, partial paralysis of the hind legs, and brain symptoms are frequently met with.

(4) The fact that paralysis of the hind legs occurred in several of these cases is of interest, owing to the fact, that there have been cases of ponies attached to Camel Corps that have been reported to have died from paralysis. It is not impossible that these ponies really died from camel surra.

Buffalo No. 1.

Aged about 6 years.

Inoculated with 1 c.c. of blood from a camel suffering from surra.

144 days after inoculation, trypanosomes were found in the blood, trypanosomes were not again observed; he died from Hæmorrhagic Septicæmia 328 days after being inoculated with surra.

163 days after being inoculated with surra a small quantity of blood was injected into a rabbit and a guinea pig—trypanosomes were found in the blood of the rabbit and guinea pig after 40 and 9 days respectively.

Buffalo No. 2.

Aged about 5 years.

Inoculated with 1 c.c. of blood from a camel suffering from surra.

The blood of this animal was examined daily for 841 days but no trypanosomes were found in the blood.

163 days after the buffalo was inoculated with surra, a small quantity of blood was injected into a rabbit and guinea pig, trypanosomes were found in the blood of the guinea pig after 19 days, and in the blood of the rabbit after 23 days.

The buffalo remained in perfect health for the 841 days he was kept under observation, he was then discontinued.

Buffalo No. 3.

Aged about 6 years.

Inoculated with 1 c.c. of blood from a camel suffering from surra.

No trypanosomes were observed in the blood; daily blood examination was made for 803 days, when he died from rupture of the diaphragm.

172 days after the buffalo was inoculated with surra, a small quantity of blood was injected into a guinea pig and rabbit; after 10 days trypanosomes were found in the blood of the guinea pig, and in the blood of the rabbit after 18 days.

Buffalo No. 4.

Aged about 5 years.

Inoculated with 1 c.c. blood from camel suffering from surra.

Trypanosomes were only once observed (11 days after inoculation) in the blood, though daily blood examination was made for 841 days.

The buffalo remained in perfect health and after 841 days was discontinued.

The blood of this animal was infective after 163 days as was proved by the injection of blood into rabbits and guinea pigs.

100 days after inoculation 1 rabbit was injected with a small quantity of blood ; trypanosomes were found in the blood of the rabbit 25 days after being injected.

163 days after inoculation 1 rabbit and 1 guinea pig were injected with a small quantity of blood ; trypanosomes appeared in the blood of the rabbit after 33 days ; the guinea pig died 42 days after being injected without trypanosomes appearing in the blood.

Buffalo No. 5.

Aged about 5 years.

Inoculated with 1 c.c. blood from a camel suffering from surra.

Seven days after inoculation, trypanosomes found in the blood. This buffalo has been under observation for 70 days only and up to the present trypanosomes have not again been found in the blood.

Improving in condition.

Buffalo No. 6.

Aged about 6 years.

Inoculated with 1 c.c. of blood from a camel suffering from surra.

9 days after inoculation, trypanosomes were found in the blood and this paroxysm lasted 5 days.

20 days after inoculation, trypanosomes were again found in the blood.

42 days after inoculation, trypanosomes were again found in the blood.

This buffalo has only been under observation 70 days.

Improving in condition.

Summary.

Buffalo No.	Age	Time under observation	Result
1	About 6 years	328 days	Died from Hæmorrhagic Septicæmia.
2	,, 5 ,,	841 ,,	Lived (discontinued).
3	,, 6 ,,	803 ,,	Died from rupture of the diaphragm.
4	,, 5 ,,	841 ,,	Lived (discontinued).
5	,, 5 ,,	70 ,,	Alive
6	,, 6 ,,	70 ,,	Alive.

Remarks :—

(1) Buffaloes do not die from inoculated camel surra.

(2) Trypanosomes do not frequently occur in the blood.

(3) Though no trypanosomes may be found in the blood, the blood is nevertheless infective, as is demonstrated in the case of Buffaloes Nos. 2 and 3; although no trypanosomes were found in their blood, the blood 163 and 172 days after inoculation was infective for rabbits and guinea pigs. This distinctly proves that buffaloes can act as a dangerous reservoir of surra; and as tabanidæ are frequently seen sucking the blood of these animals, buffaloes must not be forgotten as a probable reservoir of the disease.

(4) Buffaloes do not lose condition when inoculated with camel surra.

Dog No. 1.

Aged about 2 years.

Inoculated with 1 c.c. blood from a camel suffering from surra.

On the 9th day after inoculation, trypanosomes appeared in the peripheral circulation. The dog became very thin, developed opacity of the cornea and died 61 days after inoculation. The paroxysms during the course of the disease were very frequent.

On *post mortem* nothing abnormal but extreme emaciation.

Dog No. 2.

Aged about 2 years.

Inoculated with 1 c.c. blood from a camel suffering from surra.

Trypanosomes appeared in the blood on the 23rd day after inoculation. The paroxysms became very frequent; he developed opacity

of the cornea and died in state of extreme emaciation, 55 days after inoculation.

On *post mortem* nothing abnormal but extreme emaciation.

Dog No. 3.

Aged about 2 years.

Inoculated with 1 c.c. blood from a camel suffering from surra.

Trypanosomes appeared in the blood on the 5th day after inoculation, the paroxysms were very frequent, he became very weak, and died in an emaciated condition 37 days after inoculation.

On *post mortem* nothing abnormal but extreme emaciation.

Dog No. 4.

Aged about 2 years.

Inoculated with 1 c.c. blood from a camel suffering from surra.

Trypanosomes appeared in the blood on the 6th day after inoculation.

This dog did not lose condition rapidly. The paroxysms became very frequent and he died on the 56th day after inoculation.

On *post mortem* nothing abnormal but emaciation.

Dog No. 5.

Aged about 3 years.

Inoculated with 1 c.c. blood from a camel suffering from surra.

Trypanosomes appeared in the peripheral circulation on the 6th day after inoculation. The paroxysms became very frequent, the dog lost condition, developed opacity of the cornea and died in a state of extreme emaciation 54 days after inoculation.

On *post mortem* nothing abnormal but extreme emaciation.

Summary.

Dog No.	Age	Time under observation	Result
1	About 2 years	61 days	Died.
2	„ 2 „	55 „	Died.
3	„ 2 „	37 „	Died.
4	„ 2 „	56 „	Died.
5	„ 3 „	54 „	Died.

Remarks. From these experiments it would appear that:—

(1) Dogs inoculated with camel surra show very little resistance to the disease and die within 2 months.

(2) They become greatly emaciated and frequently show eye lesions.

GOAT No. 1.

Aged about 1½ years.

Inoculated with 1 c.c. of blood from a camel suffering from surra.

107 days after inoculation, trypanosomes (1 in specimen) were observed in the blood, but were not again found, though the blood of this goat was daily examined for 988 days.

309 days after inoculation, a small quantity of blood was injected into a rabbit and a guinea pig; trypanosomes were observed in the blood of the rabbit but not in that of the guinea pig.

This goat did not lose condition, fed well and appeared in normal health up to the time he was discontinued 988 days after being inoculated with surra.

GOAT No. 2.

Aged about 1½ years.

This goat was inoculated with 1 c.c. blood from a pony, belonging to a Camel Corps which had been found to be suffering from surra; whether this pony contracted surra from the camels of the Corps cannot be definitely stated, but taking into consideration that the pony was one of the ponies used by the Indian officers of the Camel Corps and had been a considerable time with the Camel Corps it is probable, that the pony contracted surra from the camels of the Corps.

Trypanosomes were never observed in the blood of this goat though daily examination of the blood was made for 999 days.

To test whether the blood of this goat was infective the following tests were carried out.

250 days after inoculation 1 c.c. blood from goat inoculated into rabbit; after 25 days blood of rabbit positive.

250 days after inoculation 1 c.c. blood from goat inoculated into guinea pig, blood of guinea pig negative.

321 days after inoculation 1 c.c. blood from goat inoculated into rabbit, after 11 days blood of rabbit positive.

321 days after inoculation 1 c.c. blood from goat inoculated into guinea pig, after 19 days blood of guinea pig positive.

This goat did not lose condition but kept in normal health till it was discontinued 999 days after it was inoculated.

Summary.

Goat No.	Age.	Time kept under observation	Result
1	1½ years	999 days	Lived (discontinued).
2	1½ ,,	999 ,,	Lived (discontinued).

Remarks :—

(1) Goats when inoculated with camel surra do not die (in the case of goat No. 2 the goat was inoculated with blood from a pony which probably had contracted surra from camels).

(2) They do not lose condition.

(3) Trypanosomes are seldom found in the blood of goats inoculated with surra.

Trypanosomes were only found in one, once (107 days after inoculation).

(4) Though the trypanosomes may not be found in the blood of the goats, the blood is nevertheless infective ; in the case of one goat it was proved to be infective 309 days after the goat had been inoculated and in the case of the other goat 321 days after inoculation.

Sheep No. 1.

Aged about 2 years when inoculated with 1 c.c. blood from a camel suffering from surra.

Trypanosomes were never found in the blood of this sheep, but the blood was found infective when injected into a rabbit and guinea pig.

This sheep rapidly lost condition and died 192 days after inoculation in an extremely emaciated condition.

One day before death took place the sheep suffered from acute diarrhœa.

The day before, death, a small quantity of blood was injected into a rabbit and guinea pig, trypanosomes were found in the blood of both.

On *post mortem* nothing abnormal but extreme emaciation.

Sheep No. 2.

Aged about 2 years when inoculated with 1 c.c. of blood from a camel suffering from surra.

Trypanosomes appeared in the blood 46 days after inoculation but were not found again in the blood.

The sheep became very weak and emaciated; died 384 days after being inoculated.

A small quantity of blood from the sheep, 271 days after it had been inoculated with surra, was injected into a rabbit and guinea pig, neither developed surra though their blood was examined for 43 days.

On *post mortem* nothing abnormal but extreme emaciation.

Sheep No. 3.

Aged about 2 years when inoculated with 1 c.c. of blood from a camel suffering from surra.

20 days after inoculation, trypanosomes were found in the blood.

399 days after inoculation, trypanosomes again found in the blood.

409 days after inoculation, a small quantity of blood was injected into a rabbit and guinea pig, trypanosomes were found in the blood of the rabbit 25 days later and the guinea pig died 21 days after being inoculated, without any trypanosomes being found in the blood.

569 days after inoculation the sheep had become very emaciated and died.

On *post mortem* nothing abnormal but extreme emaciation.

Sheep No. 4.

Aged about 2 years when inoculated with 1 c.c. blood from a camel suffering from surra.

24 days after inoculation, trypanosomes appeared in the blood, but were not again observed before death took place. Five days before death, the sheep became constipated and fed only fairly. It had become very weak and thin and died 88 days after being inoculated.

On *post mortem* nothing abnormal but extreme emaciation.

Sheep No. 5.

Aged about 2 years when inoculated with 1 c.c. blood from a camel suffering from surra.

Trypanosomes appeared three times in the peripheral circulation, 9, 21 and 171 days after inoculation.

Death took place 632 days after inoculation.

600 days after inoculation this sheep had become very weak, and was in an extremely emaciated condition when it died.

A small quantity of blood was injected into a rabbit and guinea pig 123 days after the last appearance of trypanosomes in the blood ; trypanosomes were found in the peripheral circulation of the rabbit and guinea pig after 20 and 27 days respectively.

Post mortem nothing abnormal but extreme emaciation.

Summary.

Sheep No.	Age	Time under observation	Result
1	About 2 years	192 days	Died.
2	„ 2 „	384 „	Died.
3	„ 2 „	569 „	Died.
4	„ 2 „	88 „	Died.
5	„ 2 „	632 „	Died.

Remarks:—

(1) Sheep are susceptible to inoculated camel surra.

(2) The trypanosomes are very infrequently found in the peripheral circulation, but the blood is infective.

(3) Sheep become gradually emaciated as the result of the disease and finally die.

(4) Sheep and goats are not so dangerous as buffaloes, from the point of view of acting as reservoirs, as they are seldom attacked by tabanidæ.

Rabbit No. 1.

Inoculated with 1 c.c. of blood from a camel suffering from surra.

Trypanosomes appeared in the blood on the 9th day after inoculation.

Showed the usual eye symptoms of surra in rabbits and died 180 days after inoculation.

Rabbit No. 2.

Inoculated with 1 c.c. of blood from a camel suffering from surra.

Trypanosomes appeared in the blood on the 10th day after inoculation.

Died 84 days after inoculation.

Guinea Pig No. 1.

Inoculated with 1 c.c. of blood from a camel suffering from surra.

Trypanosomes appeared in the blood on the 4th day after inoculation.

Died 17 days after inoculation.

Guinea Pig No. 2.

Inoculated with 1 c.c. of blood from a camel suffering from surra.

Trypanosomes appeared in the blood on the 3rd day after inoculation.

Died 75 days after inoculation.

Guinea Pig No. 3.

Inoculated with 1 c.c. of blood from a camel suffering from surra.

Trypanosomes appeared in the blood on the 4th day after inoculation.

Died 68 days after inoculation.

Summary.

No.	Time under observation	Result
Rabbit 1 . . .	180 days.	Died.
Rabbit 2 . . .	84 „	Died.
Guinea pig 1 . . .	17 „	Died.
Guinea pig 2 . . .	75 „	Died.
Guinea pig 3 . . .	68 „	Died.

Remarks. Guinea pigs and rabbits are susceptible to inoculated camel surra.